Key Operational Parameters of an Updraft Biomass Gasifier Stove

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Abstract

The objective of this study is to study key operational parameters that suite for several selected biomass fuels when operate with an updraft biomass gasifier. The biomass fuel used in the present study comprise of both woody and non-woody biomass. The woody biomass fuels are wood chip of eucalyptus and wood twigs. The non woody biomass fuels are coconut shell and corn cob. Four key operating parameters have been examined to provide an indicator for suitability of each biomass fuel when operating in the updraft gasifier. The operating parameters included start time, operating time, fuel consumption rate, flame temperature and amount of char produced. The results showed that the start time for gasification of each kind of biomass fuel depends on the characteristic of biomass fuel used. The biomass that has high density took longer time to react and ignite due to heat and mass transfer limitations. Among the biomass fuel examined here, wood chip took the longest time to ignite. Such data assists in better design and operational conditions of the gasifiers. The consumption rate is one of indicator to show the suitability of biomass fuel use. The results showed that eucalyptus wood chips had the lowest rate. The average consumption rate of wood chip was found to be 2.56 kg/h. The average flame temperature from the fuel used was in the range of 863- 967 degree Celsius.The amount of charcoal produced was in the range of 14-22 % of the original biomass.

Keywords- key operational parameters, updraft gasifier, woody biomass, and non woody biomass.

1. Introduction

. Biomass has high potential to contribute to part of the energy solution worldwide. Worldwide more than two billion people cook using biomass as fuel [1]. The use of biomass for cooking purposes is more in agricultural-rich countries. Traditional the biomass in cook stoves use combustion and have low efficiency and release increased amounts of pollutants in the kitchen where the stove is located. Many improved biomass cook stoves have been developed to overcome the above drawbacks of low efficiency and increased levels of pollutants emission [2].

Gasification is the process of converting solid fuels, such as wood, agricultural residues into a combustible synthetic gas. A biomass gasifier consists primarily of a reactor in which biomass fuel is fed and operated with limited amount of air. Heat of gasification is generated through partial combustion of the feed material. The resulting chemical breakdown of the biomass fuel involving many chemical reactions result in a combustible gas, usually called producer gas. Currently, the liquefied petroleum gas (LPG) is commonly used in many countries for household cooking because of its convenience, clean combustion and ease of use. Technology development and application for biomass gasification for cooking application are attractive [2, 3]. Wider use of the gasifier stoves could save not only on cooking fuel costs but also enhance life longevity from the combustion of clean homogeneous gas. With the escalating cost of LPG, the alternative fuels provide attractive benefits to replace the most commonly use LPG fuel in the domestic sector.

The objective of this study is to examine the key operating parameters for several selected biomass fuels in an updraft biomass fuelled gasifier stove. The results from this study will provide an indicator for suitability of each biomass fuel when operating in the updraft gasifier. The results provided here are aimed at to increased use of biomass in gasifiers with the producer gas replacing LPG for household cooking application

2. Materials and Method

A schematic diagram of the updraft gasifier stove used in the present study is shown in Fig. 1. It comprises of two main components of reaction chamber and combustion chamber. The

gasification products produced from the reaction chamber pass through the combustion chamber and combust with the supplied secondary air. The primary air is drafted upwards due to buoyancy force so that no blower is required and the amount of primary air supplied for each kind of biomass fuel can be adjusted. The secondary air is preheated from the heat released as well as from the surface of reaction chamber which helps to increase the efficiency of combustion and also reduce temperature of the outer wall surface. The burner is designed for increased mixing between the flow from the inner chamber of the gasification products and the secondary air supplied to the outer chamber.

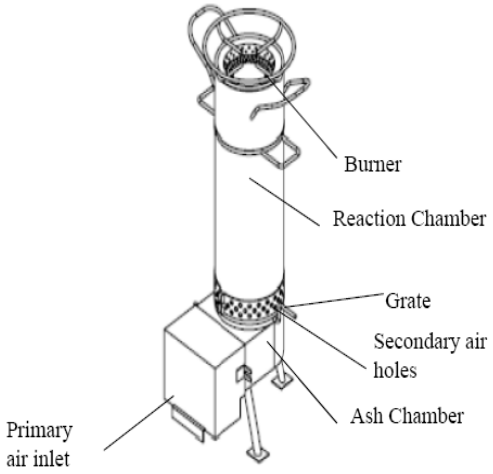

Fig.1. An updraft biomass gasifier cooking stove

The fuels used in this study comprised of both woody and non woody biomass. The woody biomass fuels used were wood chips of eucalyptus and wood twigs. The non woody biomass fuels used were coconut shell and corn cob. Photographs of the different sample biomass used here are shown in Fig. 2.

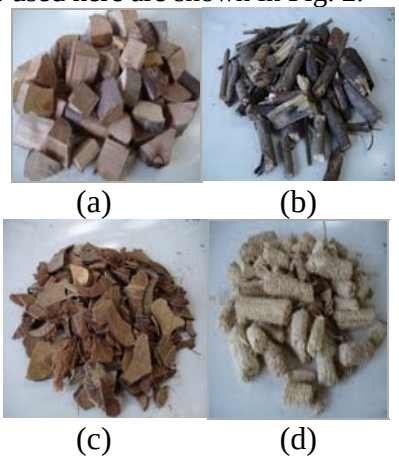

Fig 2. Biomass fuel used in the present study
(a) wood chip of eucalyptus (b) wood twig
(c) coconut shell and (d) corncob

In operation gasifier stove was charged with biomass in the reaction chamber in a batch mode and ignited from the top of the reaction chamber by using a small ignition source (such as, small pieces of paper or small wood twigs). The primary air was supplied from below the grate in the form of natural draft. The combustible gas from gasification process flow was allowed to pass through the burner holes. The secondary air flow passed through the spaces between outer and inner chamber and during its passage it also got heated from the heat released from the inner chamber. The preheated secondary air flowed out from the secondary outlet holes and subsequently mixed with the combustible gas. The experiments were conducted with several selected biomass fuel. Key operating parameters examined here included: start time, operating time, fuel consumption rate, flame temperature and amount of charcoal produced.

3. Results and Disscussion

The experimental were carried out in the updraft gasifier stove using four different kinds of biomass fuels. The operating parameters examined here comprised of start time, operating time, fuel consumption rate, flame temperature and charcoal produced. The biomass fuel used will be loaded until full of the reaction chamber thus the amount of biomass fuel used for each type are not equal.

3.1 Key operating parameters of an updraft gasifier using eucalyptus wood chips

The key operating of an updraft gasifier with wood chips of eucalyptus showed in table 1. The results from operating the updraft gasifier stove with eucalyptus wood chips as biomass fuel are now presented. The amount of wood chip loaded per batch was 2 kg.The results from testing three different times showed average start time of 14 minutes. The average operating time to gasify two kilograms of woodchip was found to be 47 minutes so that the fuel consumption rate was 2.56 kg/h. The flame temperature was approximately 863^{o}C which is quite high for the combustion of gaseous products so that no smoke was observed during operation with the above tests. The percentage of charcoal produced was 15 percents.

Table 1. Key operational parameters of an updraft gasifier using eucalyptus woodchips

Eucalypyus woodchip	test I	test II	test III	average
weight (kg)	2	2	2	2
starting time (min)	15	12	15	14
operating time (min)	43	48	50	47
fuel consumption rate (kg/h)	2.79	2.5	2.4	2.56
flame temperature (C)	820	850	920	863
charcoal (%)	15	25	20	15

Flame feature from wood chip of eucalyptus showed in Fig. 3.

Fig.3 Flame feature from gasification of wood chip

3.2 Key operating parameters of an updraft gasifier with wood twigs

The results from operating the updraft gasifier stove with wood twigs as the biomass fuel is now presented. The amount of wood twigs loaded per batch was 1.5 kg. The results from three different tests showed the average start time of 10.7 minutes. The average operating time to gasify 1.5 kilograms of wood twigs was found to be 35 minutes so that the fuel consumption rate was found to be 2.82 kg/h. The flame temperature was approximately 963^{O}C which is quite for the clean combustion of the gaseous product. As expected no smoke was observed during operation. The percentage of charcoal produced was 14.2 percents. Key operational gasification of wood twigs is shown in table 2.

Table 2. Key operational parameters of an updraft gasifier using wood twig

	test I	test II	test III	average
weight (kg)	1.5	1.5	1.5	1.5
starting time (min)	12	10	10	10.7
operating time (min)	30	32	34	35
fuel consumption rate (kg/h)	3	2.8	2.65	2.82
flame temperature (C)	960	940	990	963
charcoal (%)	13.3	16	13.3	14.2

The global flame features from gasification of wood twigs are shown in Fig. 4.

Fig. 4 Flame feature from gasification of wood twigs

3.3 Key operating parameters of an updraft gasifier with coconut shell

The results from operational experiences of the updraft gasifier stove using coconut shell as biomass fuel is now presented. The amount of coconut shell loaded per batch was 2 kg. The results from three different tests showed the average start time of 13 minutes. The average operational time to gasify 2 kilograms of coconut shell was 42.3 minutes to result in fuel consumption rate of 2.71 kg/h. The flame temperature was approximately 869 ^{o}C which is quite high for clean combustion of gaseous fuels produced from the gasifier. The observed flame features showed no observable smoke during operation. The percentage of charcoal produced was 22 percents. Key operating parameters of an updraft gasifier with coconut shell is shown in table 3.

Table 3. Key operational parameters of an updraft gasifier using coconut shell

	test I	test II	test III	average
weight (kg)	2	2	2	2
starting time (min)	15	12	12	13
operating time (min)	45	45	42	42.3
fuel consumption rate (kg/h)	2.66	2.66	2.85	2.71
flame temperature (C)	800	860	920	869
charcoal (%)	25	16	25	22

The global flame features from gasification of coconut shell are shown in Fig.5.

Fig. 5 Global flame feature from the gasification of coconut shell

3.4 Key operating parameters of an updraft gasifier with corncob

The results from operating of updraft gasifier stove with corn cob as biomass fuel are now presented. The amount of corncob loaded per batch was 2 kg. The results from three different tests showed the average start time of 11.3 minutes. The average operational time to gasify 2 kilograms of corn cob was 27.6 minutes so that the fuel consumption rate was 3.26 kg/h. The flame temperature was found to be approximately 967 ^{o}C which is considered quite high for the combustion of gaseous product so that, as expected, no smoke was observed during the operation with the gases produced from the coconut shell biomass. The percentage of charcoal produced was 22.3 percents. Key operating parameter of an updraft gasifier with corn cob is shown in table 4.

Table 4. Key operational parameters of an updraft gasifier using corncob

	test I	test II	test III	average
weight (kg)	2	2	2	2
starting time (min)	12	12	10	11.3
operating time (min)	25	30	28	27.6
fuel consumption rate (kg/h)	3.6	3	3.2	3.26
flame temperature (C)	900	920	1080	967
charcoal (%)	20	27	20	22.3

The global flame features from gasification of corncob are shown in Fig 6.

Fig. 6 Global flame feature from the gasification of coconut shell

A comparison the results from the four different biomass fuels revealed that the start time for gasification depends on characteristic of the biomass fuel used. The high density biomass takes longer time to react and ignite due to heat and mass transfer limitations. Among the biomass fuel examined here, wood chip took the longest time to ignite. The results showed that eucalyptus wood chips had the lowest rate. The average consumption rate of wood chip was found to be 2.56 kg/h. The average flame temperature from the fuel used was in the range of 863- 967 ^{o}C. The amount of charcoal produced was in the range of 14-22 % of the original biomass. Such data assists in better design and operational conditions of the gasifiers.

4. Conclusions

Four key operating parameters have been examined to provide an indicator on the suitability of each defined biomass fuel use in an updraft gasifier. The biomass fuel used in the present study comprised of both woody and non-woody biomass. The woody biomass fuels were eucalyptus wood chips and wood twigs. The non woody biomass fuels were coconut shell and corn cob. The operating parameters included start time, operational time, fuel consumption rate, flame temperature and amounts of char produced. The results showed that the start time for gasification for the examined biomass fuel depends on characteristic of the biomass fuel used. The high density biomass takes longer time to react and ignite due to heat and mass transfer limitations. Among the biomass fuel examined here, wood chip took the longest time to ignite. Such data assists in better design and operational conditions of the gasifiers. The consumption rate is one of indicator to show the suitability of biomass fuel use. The results showed that eucalyptus wood chips had the lowest rate. The average consumption rate of wood chip was found to be 2.56 kg/h. The average flame temperature from the fuel used was in the range of 863- 967 ^{o}C. The amounts of charcoal produced was in the range of 14-22 % of the original biomass.

5. Acknowledgements

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