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PERFORMANCE TEST OF RICE HUSK GASIFIER AS AN ALTERNATIVE FUELS DERIVED FROM NATURAL GAS OR LPG FOR CERAMICS FIRING

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ABSTRACT

Biomass gasification is more benefit compared to direct combustion because of more flexibility gas product that can be directed use as combusted gas in gas engine power generation or ceramics firing as well as synthetic fuel belongs to added market value. Performance test of prototype 20 kW thermal downdraft gasifier using feed of 15 kg/h rice husk and air as the gasifying agent conducted to determine the ability of syngas combustion thermal gasification, and syngas combustion temperature stability. The maximum temperature of gasifier reached 824.5^oC at minute 34, while the minimum temperature occurred at 59 minutes of 476.5^oC due to distracted by rice husk feeding inside gasifier. So the average temperature during the gasification process is 733.5^oC. The syngas quality of rice husk gasification results using fixed-bed downdraft gasifier is not strongly influenced by air injection as gasifying agent, however by injection of steam mixed by air as gasifying agent will increase the H_2/CO ratio. The quality of syngas depends on arrangements of rice husk feeding, the ratio of air / gas into the gasifier, and spending the rest of ash, in order to obtain a stable and constant flame and temperature. The quality of syngas by the ratio H_2/CO = 0.35 and the average temperature during gasification has been sufficient to meet the requirements of quality feed as fuel for ceramic firing.

Keywords : rice husk, downdraft gasifier, synthetic gas, ceramic firing

1. INTRODUCTION

Ceramic industry is an energy intensive industries and labor-intensive that utilize the potential of natural resources (clay, feldspar and silica sand) will continue to grow with high competitiveness both the capacity and the type and design of the product. The industry has made significant contributions in support of national development by providing domestic demand, foreign exchange earnings and employment. This condition can be seen from the supply domestic demand growth averaging about 6%, and foreign exchange earnings reached U.S. $ 220 million (2008), an increase compared with 2007 amounted to U.S. $ 212 million, as well as the employment of more than 200,000 people. So that the Indonesian places itself as the world's largest ceramics producer after China, Italy, Spain, Turkey and Brazil.

Ceramics are a variety of chemical industry products resulting from the processing of minerals (kaolin, feldspar, silica sand and clay) through high temperature combustion stage (± 1300^oC) which can be achieved by using fuel gas.

One of the problems faced by the ceramic industry today is the supply of natural gas fuel not be guaranteed for the long term. In addition, natural gas prices are set in USD so if rupiah exchange rate

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weakened against the USD would lead to higher cost of production.

In addition to natural gas, there is also a ceramic industry that use liquefied petroleum gas (LPG) as aids a ceramic paint spraying ceramic as well as heater fuel that dries quickly and is formed as expected, so it is very helpful to the potters, because it can save the cost of production. Through the perfect heating will be more efficient use of LPG, compared with kerosene or firewood.

However, with the increased consumption of subsidized LPG as a consequence of the conversion program from kerosene to LPG which is not matched by domestic production capabilities result in higher dependence on imported LPG. Thus, the development of alternative fuels derived from natural gas or LPG into the increasingly strong demand, in which fuel is certainly having an impact on society, al: greenhouse gases, the amount of reserves, suitability and ease of use, infrastructure, availability, economical, and safe.

As an agricultural country, efforts to the development and utilization of biomass to be very prospective accordance Presidential Regulation No. 5 of 2006 on National Energy policy in developing renewable energy sources that are environmentally friendly as an alternative to solve energy crisis.

2. LITERATUR REVIEW

Biomass containing cellulose, hemi-cellulose, lignin ($C_6H_{10}O_5$), oxygen excess and low calorific value ranging from 12-16 MJ / kg [6] has a high potential in contributing to the energy needs of modern society. Just selected biomass that can be converted into biogas, ethanol, biodiesel through chemical and biochemical processes, otherwise most biomass materials can experienced thermochemical conversion, making this process more interesting than others.

Among thermochemical conversion technologies, biomass gasification has attracted the attention of that offer higher efficiencies than combustion. In the complete combustion of biomass in theory stoichiometri amount of air consumption = 6-6.5 kg of air / kg of biomass with end product CO_2 and H_2O. In the gasification, biomass experienced partial pyrolysis sub-stoichiometri condition with a limited air 1.5-1.8 kg of air / kg of biomass [5].

Interest in biomass gasification reoccurs after the energy crisis of the 1970s. Gasification technology began to be perceived as a relatively inexpensive alternative for small-scale industrial and utility power plants, particularly for developing countries that suffer because of high oil prices while having sufficient availability of biomass resources [8].

Gasification is a partial oxidation process between carbon and gasifying agent (air/O_2/*steam* or mixtures) at temperature around (500–1400ºC) which produce producer gas (synthesis gas or syngas) CO, H_2, CO_2, CH_4, high hydrocarbon i.e: ethane, ethene, H_2O steam, N_2 (if the air used for oxidation agent) and various impurities (small particles of charcoal, ash, tar, oil). Gasification relies on chemical processes at elevated temperatures (500–1400ºC) distinguishing of biological processes such as anaerobic digestion that produce biogas [5].

Figure 1 shows the differences in design and characteristics of the reaction zone fixed-bed gasifier, in which the fuel particles is not driven by the flow of gas to the fuel arranged in a fixed bed gasifier. Most of the fuel feed is placed on a pedestal fluidized–bed while the rest of the combustion in the form of charcoal and ash removed from the bottom of the pedestal fuidized–bed. Biomass fuel moves from the top to the bottom of the fuel bed pedestal so that the residence time of fuel in the gasifier is relatively long.

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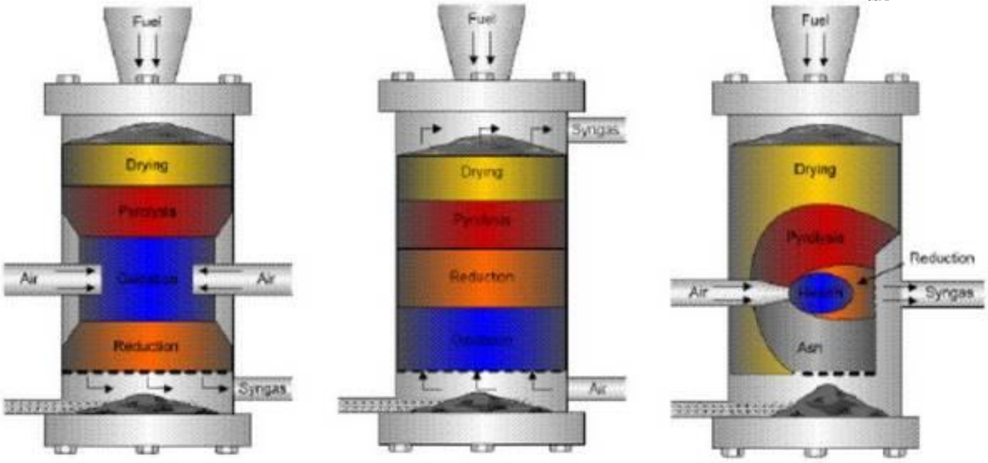

Figure 1. Differences in design and characteristics of the reaction zone fixed-bed gasifier [7]

Special design consists of a gasifier feeding fuel from the bottom of the fuel bed pedestal. Depending on the direction of the product gas flow to the direction of transport fuels in the fixed-bed gasifier classified into co-current (unidirectional), counter-current and cross-flow. The gasification process stages occurs in four (4) zones, namely drying (>150°C), pirolysis (150°C<T<700°C), oxydation (700°C<T<1500°C), and reduction (800°C<T<1000°C).

Pyrolysis or devolatilization is a series of physical and chemical processes occurring slowly at temperatures <350°C and rapidly at temperatures> 700°C. Composition of the gas product composed is a function of temperature and pressure during pyrolysis takes place.

Pyrolysis process starts at temperatures around 230°C, when the component thermally unstable, such as lignin broke and evaporates along with other components. Vaporized liquid product containing tar and PAHs (polyaromatic hydrocarbons). Pyrolysis products are generally composed of light gases (H_2, CO, CO_2, H_2O, CH_4), tar, and char.

Oxidation is the most important reactions occurring in the gasifier which provide all the energy needed to heat the endothermic reaction. Oxygen is supplied to the gasifier reacts with combustible material. The reaction products are CO_2 and H_2O are sequentially reduced when in contact with the charcoal produced in pyrolysis.

Another reaction that takes place is the oxidation of hydrogen contained in the carbon material formed steam

$$H_2 + {}^1/_2\, O_2 \rightarrow H_2O + 742\ \frac{kJ}{mol\ H_2}$$

Reduction or gasification reaction that includes a series endothermic supported by the heat produced from the combustion reaction. The resulting product is a fuel gas, such as H_2, CO, and CH_4. There are four (4) common reactions associated gasification process, namely:

Water–gas reaction is a partial oxidation reaction of carbon by steam which can be derived from the pyrolysis of solid fuels itself and of the water vapor is mixed with air and water vapor evaporation results.

$$C + H_2O \rightarrow H_2 + CO - 131{,}38\ \frac{kJ}{mol\ C}$$

Boudouard reaction is the reaction between CO_2 that occur in the gasifier with CO to produce char.

$$C + CO_2 \rightarrow 2\ CO - 172{,}58\ \frac{kJ}{mol\ C}$$

Shift conversion is the CO_2 reduction reaction by steam to produce H2. This reaction is known as the water-gas shift which results in an increase in the ratio of H_2/CO_2 gas producer to manufacture syngas.

$$CO + H_2O \rightarrow CO_2 + H_2 - 41{,}98\ \frac{kJ}{mol}$$

Methanation a gas-forming reaction CH_4.

$$C + 2\ H_2 \rightarrow CH_4 + 74{,}90\ \frac{kJ}{mol\ C}$$

Fixed bed gasification system consists of a gasifier is equipped with cooling and gas cleaning systems. Fixed-bed gasifier has a pedestal bed of solid fuel particles, gasifying agent and gas moves slowly up and down so that the gasification reaction occurs with high carbon conversion, residence time of fuel relative, low gas velocity and low recovery ash [2].

The simple gasifier typically consist cylindrical chamber made of firebricks with foundation steel and concrete for fuel gasification and feeding agent to the unit, the unit discharge ash and gas output. In the *fixed–bed gasifier* experiencing difficulties in tar waste problem, but now the conversion progress in thermal and catalytic tar provide a reliable option. Cooling and gas cleaning system consists of filtration through the cyclone, the absorption of dry / wet (dry/wet scrubbers) [2].

There are many types of fixed-bed gasifier with a variation of reactor design and gasifyig agent can be classified according to how the gasifyig agent entrance gasifier, namely: updraft, downdraft, and crossdraft gasifier. Gasifyig agents can be air, steam, O_2 or mixtures and producer gas can be used as a heating or power generation applications. Diversity of producer gas composition and contamination level depends on the selection of biomass, gasifier type and operating conditions [1].

Table 1. Syngas composition by gasifying agent used

Gas Component %vol. dry	Gasifying Agents		
	Air	Air (80% O_2)	*Steam*
CO	10 – 20	40 – 50	25 – 47
H_2	9 – 20	9 – 17	35 – 50
CH_4	1 – 8	<1	14 – 25
CO_2	10 – 20	19 – 25	9 – 15
N_2	40 – 55	15 – 30	2 – 3
Calorific Value (MJ/Nm^3, dry)	4 – 6,5	7 – 9	12 – 17

Source: Bioenergiesysteme GmbH

Updraft gasifier is a type of the oldest and simplest fixed-bed gasifier that can handle biomass fuels with high ash content (>15%) and high water content (>50%), but less sensitive to the diversity of size and quality of the biomass. In the counter-current updraft gasifier, biomass entering from the top of reaction chamber and the gasifying agents (air, O_2 or mixtures thereof) entered from the bottom grate. Fuel flows slowly down through the 4 stages of zones, namely: drying, pyrolysis, gasification and combustion, and ash removed from the bottom.

Updraft gasifier has a sensible heat efficiency of high gas producer that can be obtained through direct heat exchange with the pyrolysed fuel feeding experiencing dry before entering the gasification zone. Producer gas out at low temperatures (80~300ºC) and tar rich in oil content (10~20%) considering the products from the pyrolysis and drying zone issued directly without experiencing decomposition. Dust content of the producer gas is low because the gas velocity is slow and the impact on the fuel feed filtration drying and pyrolysis zone [2], [8].

Downdraft fixed-bed gasifier designed stainless steel coated cylinder, where combustion reactions take place in the smaller cylinder is made of high temperature steel is placed inside the outer cylinder. Fuel breaks grate attached to the bottom of the reaction chamber combustion periodically shaken by two rods to let the ash fall on the base plate main room.

Some fuel feeding through the base plate holes for entering air and K type thermocouple (Omega) into the combustion chamber to monitor the reaction temperature. Two cartridge heaters inserted in the combustion chamber wall to initiate biomass combustion using air as agasifying agent supplied from a compressor that has a pressure regulator and rotameter.

The fuel is fed from the top through the director funnel into the combustion chamber. During the combustion process, combustion chamber is closed in order to syngas move downward through the holes of the fireplace that is directed to the channel between the combustion chamber and the outer cylinder. Syngas which leads out to a Bunsen burner that burns in a hood [4].

In the crossdraft gasifier, the fuel moves downward while air is introduced on one side and the producer gas (800-900^{o}C) out of the opposite side, while the ash removed from the bottom of the gasifier. Overall energy efficiency is low and tar content is high in the producer gas are mostly used for boiler closed circuit. Crossdraft type gasifier has limitations tar chap, so it is only suitable for low tar fuel, the implementation does not lead to industrial scale [3], [8].

Application of biomass gasification mainly carried out in the fixed-bed and fluidized-bed gasifier. Fixed-bed gasifier is the most practical option for producing low calorie gas and suitable for use in small-scale power plants (<10 MWth) or heating applications, while the fluidized-bed gasifier is very effective to be applied on a larger scale power plants (> 15 MWe) [2].

The potential use of the syngas is more efficient than direct combustion, as it can burn at higher temperatures, so that the thermodynamic efficiency defined by Carnots higher or even not feasible applicability. Syngas can be burned directly in internal combustion engines to produce methanol and H_2, or converted via the Fischer-Tropsch Synthesis becoming synthetic fuel.

3. RESEARCH

Performance test of prototype 20 kW thermal downdraft gasifier using feed of 15 kg/h rice husk and air as the gasifying agent conducted in workshops manufacturer PT. ELCO Sidoarjo and PUSPIPTEK Serpong to determine the ability of syngas combustion thermal gasification, and syngas combustion temperature stability. Measurement parameters include: the flame temperature at the point of combustion syngas on the burner, the 3" blower openings to blow air into the gasifier, the 2" blower openings for burning syngas.

3.1. Purpose

Socializing the results of synthetic gas from biomass gasification as an energy alternative to natural gas/LPG for Small and Medium Enterprises Ceramics.

3.2. Materials

- Rice husk as raw material is fed from the silo (15 kg/hour) into the gasifier, with specifications as shown in Table 1.
- Air (ρ = 1,16 kg/m^3, μ = 1,84 10^{-5} N.sec/m^2, g = 9,807 m/sec^2) as gasifying agent is fed through air blower into gasifier.

Table 2. Specification of rice husk

Compound		Composition
Cellulose		: 35%w
Hemicellulose		: 25%w
Lignin		: 20%w
Crude Protein		: 3%w
Ash (Silica)		: 17%w
Proximate Analysis		Composition
Volatile Matter	VM	: 60,30%w
Fixed Carbon	FC	: 17,00%w
Ash		: 22,70%w

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Ultimate Analysis		Composition
Carbon	C	: 29,33%w
Hydrogen	H	: 3,90%w
Oxygen	O	: 29,17%w
Nitrogen	N	: 0,24%w
Sulfur	S	: 0,16%w
Water	H_2O	: 22,70%w
Ash		: 14,50%w
Physical Properties		
Diameter	∅	: 0,5 mm
Density	ρ	: 300 kg/m^3
Spericity	φ	: 0,65
Porosity		: 0,5

Source: PT. ELCO

3.3. Equipments

3.3.1. Downdraft fixed–bed gasifier thermal 20 kW (h : 295 cm) with rice husk feeding (Figure 2) consisting of:

- Hopper : h = 42.5 cm, ϕ = 46 cm
- Body : h = 126 cm, ϕ = 46 cm
- Furnace : h = 90 cm, ϕ = 72 cm

3.3.2. Scrubber (h : 95 cm, ϕ = 23.5 cm)

3.3.3. Gas deposite (h : 75 cm, ϕ = 23.5 cm)

3.3.4. Burner & Pipe (L : 125 cm)

3.3.5. Blower (1 unit 2" and 1 unit 3")

Figure 2. Prototype downdraft fixed–bed gasifier thermal 20 kW (rice husk) PT. ELCO

3.4. Metodology

3.4.1. Start–up

- Prepare rice husk dried (15 kg/hour):
- Prepare a tank filled with water until submerged water drain holes:
  - Bak 1 under the gasifier as a shelters rice husk ash
  - Bak 2 under the scrubber as a reservoir of water + particulate
- Prepare sealant

3.4.2. Operation

- Place the hopper on the top of gasifier, put sealant on the connection or newspaper to prevent leakage
- Put air blower 3" with 0 next to the hopper and the discharge of water blower 2" with 0 discharge in the water scrubber
- Make sure the bottom of ash disposal, rice husk in a closed condition (horizontal). Enter rice husk ash into the gasifier to fill the inverted cone-shaped space at the bottom of the gasifier.
- Turn on the aquarium pump to circulate the water in the tank into the water scrubber. Better yet, if the water is flowed into a water scrubber is clean water from the tap, so it's not water circulation results.
- Open the hole cover located on three sides of the gasifier body, and enter the diesel oil moistened newsprint to start burning rice husk in the gasifier.
- Open the syngas output valve also to flare stack, syngas output valve to the burner, and the air outlet valve from air blower.
- Open the hopper cap then enter 4 small bags (weight ± 15 kgs) of dry rice husks into the gasifier.
- Burn newsprint that had been installed on three sides of the hole. Make sure the rice husks are burned in the gasifier.
- The hopper cap, and turn on the blower 3" with a maximum openings so that the smoke out through the flare stack and burner for 10 minutes.
- Close the valve, just let the smoke out through the burner hole.
- Turn on the blower 2” and let the smoke flowing out for 30-45 minutes until completely formed syngas.
- Light a match to burn syngas coming out of the burner.
- If you can not burn syngas resulting syngas quality is still not good. The thing to do is put one small sack of rice husk gasifier hopper into that is balanced with throwing rice husk ash through the bottom of the gasifier. Allow 10-15 minutes and try to burn again.
- If it is burned, continue to monitor the temperature burner. Waste rice husk ash on a regular basis which is always balanced with charging rice husk (usually every 10-15 minutes once) so that good quality gas and could continue to burn with a relatively constant temperature (up to ± 800°C).

3.4.3. Shutdown

Total turn off (OFF), the intention is to stop the operation of the gasifier in total and clean all equipment gasifier. The steps to be performed are:

- Turn off the blower and pump, then put it in storage
- Take a reservoirs under the gasifier and water scrubber.
- Remove ash and the rest of rice husk through the bottom of the gasifier to clean, if necessary knock the gasifier body in order to rice husk can stick down.

4. RESULT AND DISCUSSION

The operation of performance test for rice husk gasifier systems using air as gasifying agent with rice husk feeding of 15 kg / hour during the 6-hour effectively test with measurements for 3 hours after the last stable gasification shown in Figure 3.

4.1. Results

Table 3 shows measurement results of the flame temperature at the point of combustion syngas on the burner for 3 hours after the last stable gasification.

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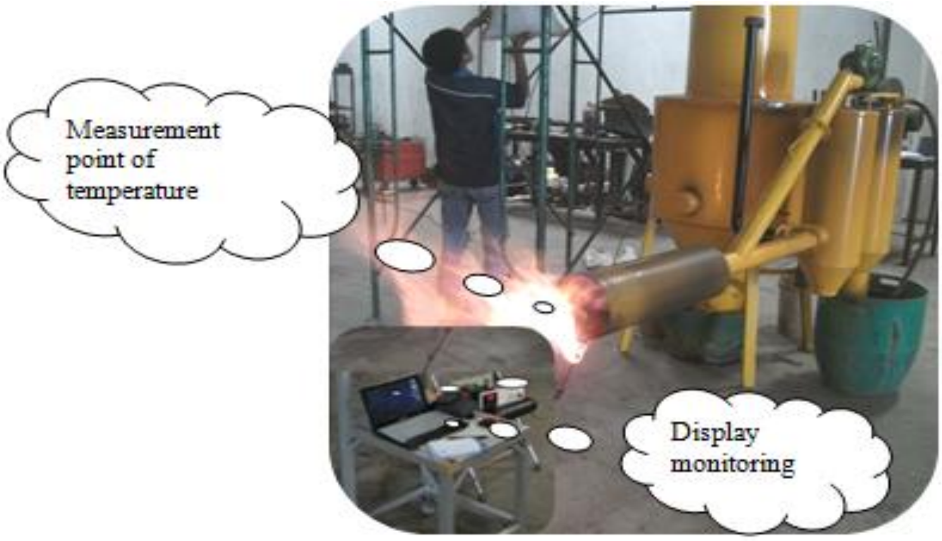

Figure 3. Performance test of rice husk gasifier systems using air as gasifying agent

Table 3. Measurement results of the flame temperature at the point of combustion syngas on the burner for 3 hours

Minutes to	Temperature (°C)	Remarks	% Openings Blower 3”	% Openings Blower 2”
0	746.6		100%	100%
1	740.1	Entering 1 sack of rice husk	100%	100%
2	730.6		100%	100%
3	671.2		100%	100%
4	681.3		100%	100%
5	764.7		100%	100%
6	793.0		100%	100%
7	770.5		100%	100%
8	745.6		100%	100%
9	743.7		100%	100%
10	751.0		100%	100%
11	740.1		100%	75%
12	712.3		100%	75%
Minutes to	**Temperature (°C)**	**Remarks**	**% Openings Blower 3”**	**% Openings Blower 2”**
13	698.2		100%	50%
14	708.8		100%	50%
15	696.3		100%	50%
16	687.2		100%	50%

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17	679.4		100%	50%
18	666.3		100%	50%
19	645.7		100%	50%
20	634.3		100%	50%
21	610.3	Ash removed Entering 1 sack of rice husk	100%	0%
22	709.1	Ash removed	100%	0%
23	737	Ash removed	100%	0%
24	725.6	Ash removed	100%	50%
25	713.9	Ash removed	100%	50%
26	750.6		100%	50%
27	781.2		100%	50%
28	788.4		100%	50%
29	806.5		100%	50%
30	797		100%	50%
31	794.5		100%	50%
32	811.1		100%	100%
33	820		100%	100%
34	824.5	Maximum temperature	100%	100%
35	824.4		100%	100%
36	821.9		100%	100%
37	814.2		100%	100%
38	822.8		100%	100%
39	820.5		100%	100%
40	813.7		100%	100%
41	805.6	Entering 0.5 sack of rice husk	100%	100%
42	797.8	Entering 0.5 sack of rice husk	100%	100%
43	780.7		100%	100%
44	783.5		100%	100%
45	795.9		100%	100%
46	795.3		100%	100%
47	785.7	Ash removed	100%	100%
48	777.4	Entering 1 sack of rice husk	100%	100%
49	751.8		100%	100%
50	692.4		100%	25%
51	727.6		100%	25%
52	757.5		100%	25%
Minutes to	**Temperature (^oC)**	**Remarks**	**% Openings Blower 3”**	**% Openings Blower 2”**
53	758.6		100%	25%
54	773.9		100%	50%

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55	754.7		100%	50%
56	683	Ash removed	100%	100%
57	614.2	Ash removed	100%	100%
58	496.7	Entering 1 sack of rice husk	100%	100%
59	476.5	Minimum temperature interrupted when the husk entry	100%	100%
60	559.4		100%	100%
61	709		100%	100%
62	806.2		100%	100%
63	790.9		100%	100%
64	776.5		100%	100%
65	773.5		100%	100%
66	780		100%	100%
67	792.5		100%	100%
68	767.6		100%	100%
69	650		100%	100%
70	716.6		100%	100%
71	779.4	Ash removed, Entering 1 sack of rice husk	100%	100%
72	819.9		100%	100%
73	821.5		100%	100%
74	814.4		100%	100%
75	801.1		100%	100%
76	771.9		100%	100%
77	765		100%	100%
78	761.6		100%	50%
79	747		100%	50%
80	731.6		100%	50%
81	721.2		100%	50%
82	710.6		100%	50%
83	701.9		100%	50%
84	699.2	Ash removed, Entering 1 sack of rice husk	100%	50%
85	722.3		100%	50%
86	730.0		100%	50%
87	731.5		100%	50%
88	724.7		100%	50%
89	715.0		100%	50%
90	702.1		100%	50%
91	748.5		100%	50%
92	751.2		100%	50%

Minutes to	Temperature (^oC)	Remarks	% Openings Blower 3"	% Openings Blower 2"
93	747.6		100%	50%
94	754.9		100%	50%
95	777.3		100%	50%
96	785.9		100%	50%
97	762.1		100%	100%
98	782.1		100%	100%
99	809.2		100%	100%
100	768.4		100%	100%
101	758.1		100%	100%
102	753		100%	100%
103	736.8		100%	100%
104	710.8		100%	100%
105	701.5		100%	100%
106	697.4		100%	100%
107	715.5		100%	100%
108	716.3		100%	100%
109	705.8		100%	100%
110	695		100%	100%
111	684.3		100%	100%
112	674.0		100%	100%
113	666.6	Stirring rice husk in the hopper	100%	100%
114	677.4		100%	100%
115	729.3	Ash removed, Entering 0.5 sack of rice husk	100%	100%
116	749.8		100%	100%
117	713.0		100%	100%
118	714.5		100%	100%
119	729.3		100%	100%
120	726.3		100%	100%
121	701.7		100%	100%
122	715.1		100%	100%
123	707.6		100%	100%
124	712.6		100%	100%
125	740.3		100%	100%
126	748.2		100%	100%
127	740.1		100%	100%
128	747.8		100%	100%
129	768.4		100%	100%
130	803.1		100%	100%

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131	801.6		100%	100%
132	806.1		100%	100%
133	822		100%	100%
Minutes to	**Temperature (°C)**	**Remarks**	**% Openings Blower 3"**	**% Openings Blower 2"**
134	812.2		100%	100%
135	743.6		100%	50%
136	670.2		100%	50%
137	666	Ash removed, Entering 0.5 sack of rice husk	100%	50%
138	690.7		100%	50%
139	674.5		100%	50%
140	650.1		100%	50%
141	631.8		100%	50%
142	620.3		100%	50%
143	595		100%	50%
144	583.4		100%	50%
145	490.5	Ash inside already too much	100%	50%
146	667.3		100%	25%
147	754.7		100%	25%
148	760.4		100%	25%
149	762.2		100%	100%
150	779.3		100%	100%
151	795.6		100%	100%
152	788.5		100%	100%
153	732.3		100%	100%
154	759.8		100%	100%
155	806.7		100%	100%
156	816.8		100%	100%
157	812.4		100%	100%
158	798.5		100%	100%
159	760.3		100%	100%
160	745.2		100%	100%
161	730.7		100%	100%
162	714.8		100%	100%
163	672.6	Flames die	100%	100%
164	572.4	Fire turned on	100%	25%
165	706.8	Ash removed	100%	25%
166	697.6		100%	25%
167	680.1		100%	25%
168	663.3	Ash removed, Entering 1 sack of rice husk	100%	25%

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169	701.8		100%	25%
170	701.2		100%	25%
171	703.4	Ash removed, Entering 1 sack of rice husk	100%	25%
172	730.9		100%	25%
173	713.5		100%	25%
174	704.2		100%	25%
Minutes to	**Temperature (^oC)**	**Remarks**	**% Openings Blower 3"**	**% Openings Blower 2"**
175	721.8		100%	25%
176	733.9		100%	25%
177	746.6		100%	25%
178	754.7		100%	25%
179	760.1	Gasifier "OFF"	100%	25%

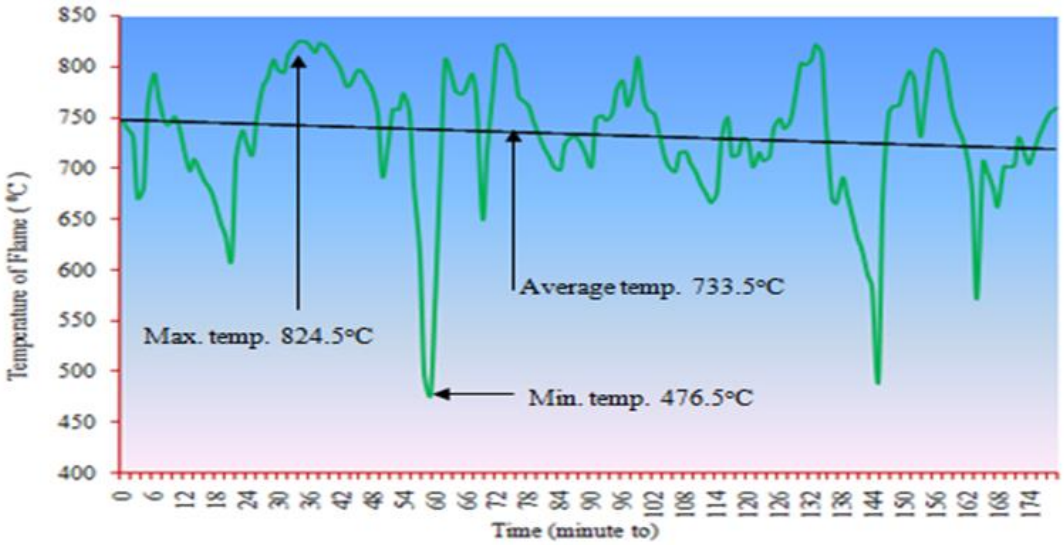

Figure 4. The influence of operation time towards tmperature of flame during gasification

Table 4 shows the standard gas composition (according to the label, GC, and calculations) that used for instrument calibration Gas Chromatography.

Table 4. Standard gas composition

Compound	Standard Gas , %		
	Label	GC	Calculation
N_2	83,00	82,5347	55,0000
H_2	5,09	5,6689	14,6061
CO	5,18	5,1433	13,2519
CH_4	1,05	1,0379	2,6742
CO_2	5,68	5,6152	14,4678
Total	100	100	100

Table 5 shows the syngas composition of rice husk gasification results using air as gasifying agent.

Table 5. Syngas composition of rice husk using air as gasifying agent

Component	Syngas content, %	
	GC	Calculation
N_2	79,3842	55,0000
H_2	1,2939	2,8243
CO	3,7162	8,1117
CH_4	2,6890	5,8695
CO_2	12,9168	28,1947
Total	100	100
Ratio H_2/CO		0,35

Figure 4 shows the influence of operation time towards tmperature of flame during gasification.

4.2. Discussions

Figure 4 shows that the maximum temperature of gasifier reached 824.5°C at minute 34, while the minimum temperature occurred at 59 minutes of 476.5°C due to distracted by rice husk feeding inside gasifier. So the average temperature during the gasification process is 733.5°C.

Table 5 shows that syngas quality of rice husk gasification results using fixed-bed downdraft gasifier is not strongly influenced by air injection as gasifying agent, however by injection of steam mixed by air as gasifying agent will increase the H_2/CO ratio.

The quality of syngas by the ratio H_2/CO = 0.35 as shown in Table 5, and the average temperature during gasification as shown in Figure 4 has been sufficient to meet the requirements of quality feed as fuel for ceramic firing.

5. CONCLUSSIONS

Based on the results and discussions above mentioned, it can be concluded some of the following:

- The quality of syngas depends on arrangements of rice husk feeding, the ratio of air / gas into the gasifier, and spending the rest of ash, in order to obtain a stable and constant flame and temperature.
- Injection of steam mixed by air as gasifying agent will increase H_2/CO ratio, thus increasing the quality syngas.

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