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ADDITIVE INFLUENCE ON GASIFICATION OF PALM OIL EMPTY FRUIT BUNCH PELLET

RINGKASAN: Kajian terhadap keboleh-laksanaan gasifikasi kepada tandan sawit kosong (EFB) menggunakan loji gasifikasi sedia ada milik Stadtwerke Rosenheim Germany mengambil kira ciri-ciri kimia EFB tersebut. Dalam kajian ini, ujikaji gasifikasi dengan pelet EFB telah dijalankan di Rosenheim, Jerman menggunakan loji gasifikasi yang beroperasi sepenuhnya milik Stadtwerke Rosenheim. Kajian telah dijalankan dengan campuran kepada cip kayu spruce memandangkan telah diketahui kandungan potassium dan habuk adalah tinggi dan suhu melembut yang rendah untuk pelet EFB. Kajian tersebut telah dijalankan dengan 2 jenis campuran iaitu 33 % EFB dan 67 % cip kayu dan 33 % EFB and 67 % cip kayu dengan bahan tambahan. Bahan tambahan telah ditambah untuk mengurangkan nisbah berat potassium dan meningkatkan suhu melembut.Gasifikasi tanpa bahan tambahan tidak berjaya dijalankan untuk jangka masa yang panjang manakala dengan bahan tambahan gasifikasi dapat dijalankan sehingga 10 jam dengan amaun penghasilan gas, nilai kalori dan keberkesanan gas sejuk yang setara dengan gasifikasi dengan 100 % cip kayu. Oleh yang demikian, rekabentuk gasifikasi yang lebih sesuai perlu diterokai dengan mengambil kira sifat kimia EFB. Penambahan bahan tambahan kepada EFB sebelum ianya dipeletkan juga perlu dilaksanakan bagi membolehkan EFB dapat digasifikasikan pada suhu tinggi agar jumlah tar dilepaskan dapat dikekalkan pada kuantiti yang rendah.

ABSTRACT: In this research, a gasification experiment using Empty Fruit Bunch (EFB) pellets was carried out in Rosenheim, Germany, using a fully functioned gasification plant developed and owned by Stadtwerke Rosenheim. The research was conducted with a mixture of spruce wood chip and EFB. This is because EFB has high ash content and to reduce the total ash in the feedstock, spruce wood was mixed. . In addition the softening point of ash from EFB is low which will likely have an agglomeration issue at high temperature. The research was conducted in 2 different mixtures which include 33 % EFB and 67 % wood chip and 33 % EFB and 67 % wood chip with addition of additive. The additive was added to reduce the ash

potassium content and increase its softening point. Gasification without additive did not manage to run in long hours as agglomeration built up in the reactor while with additive, the gasification managed to run for about 10 hours with 2.98 m³/kg of gas yield, cold gas efficiency recorded at 83.31 % and the calorific value of the feed stock mixture is 5.30 MJ/m³, comparable to gasification with 100 % of wood chips. Therefore a suitable gasification design has to be explored in the future considering the properties of EFB. Apart from the gasification reactor, pelletizing of EFB has to be premixed with additive in order to enable the EFB to be gasified at high temperature to enable the production of a quality gas without a risk of agglomerations.

INTRODUCTION

Malaysia through its various schemes has introduced several policies to enhance the application of Green Energy and Energy Efficient Building. A new technology has to be explored to vary the available green energy in Malaysia considering resources, cost and practicality. As a country that generates millions of tons of agricultural and forestry residues, gasification technology can be considered as one of the most suitable technics to generate green renewable energy.

Gasification is a process of thermal conversion of solid material into a gaseous product in a limited air supply. This is done at a high temperature range by reacting the solid fuel at high temperatures with a controlled (limited) amount of oxygen. In this process, a combustible gas such as carbon monoxide (CO), hydrogen (H_2) and a trace of methane (CH_4) is produced (Phillips, 2006). A big challenge in gasification is the formation of residues inside the gasifier that is caused by the ash content of the fuel. The ash component of biomass is inorganic and therefore non-reactive and cannot be converted into biofuels. The forming of ash inside the gasifier will reduce heat transfer and efficiency of the gasification process. This is done as it fuses together to form slag and influence the downward flow of biomass feed. It is also affecting the heat transfer negatively by sheltering some point in fuel and thus delays the fuel reaction response (Rajvanshi, 1986). If the temperature exceeds the softening temperature of the ash, it will form slags, hard, slightly foam like mineral layers in the gasifier (Williams *et al.*, 2007) with a low heat transfer coefficient.

Slag formation is mainly influenced by the gasification feedstock. Feedstock with high ash content and low softening point such as palm oil EFB, will more likely to form a slag. Elements such as Ca and Mg increase the ash melting point while K

and Na decrease the melting point. Chlorides and low melting alkali and alumino silicates may decrease the softening point (Friedrich Biederman, 2005).

Fuel Composition and Layer Formation

Compared with spruce wood, that is commonly used as a gasification feedstock in most European countries, EFB has a significant difference in composition, especially in terms of ash component. EFB ash is rich in K, Na, Ca, Mg, Si and C in the ash content and consequently the melting points are comparatively lower than other ash derived from spruce wood. These differences explain the performance of both feed stocks in gasification (Carl Wilen, 1996).

Fuel Analysis

The ash melting point is a concern of the performance of gasification with EFB pellets. Comparison for both woodchips and EFB pellets is shown in Table 1. Lower ash melting point, particularly the softening temperature demonstrates that the ash would soften as the ash reaches the temperature. Therefore, the higher the softening temperature, the better the fuel since it is able to withstand a higher temperature and avoid from forming of slag. This could reduce the downtime for major overhaul of the gasifier (Williams *et al.*, 2007). Both characteristics would give a different approach and resulting in gasification in both feed stocks.

Table 1. Comparison of chemical properties of EFB pellets and wood chips in terms of contributing factors to agglomeration.

No.	DESCRIPTION	UNIT	EFB PELLETS	WOOD CHIPS
A	Contributing Elements to High Softening Point			
	Ca	mg/kg d.b	3720[1]	900[3]
	Mg	mg/kg d.b	1650[1]	150[3]
B	Contributing Elements to Low Softening Point			
	K	mg/kg d.b	12,100[1]	400[3]
	Na	mg/kg d.b	481[1]	20[3]
	Si	mg/kg d.b	37,900[1]	150[3]
	Cl	mg/kg d.b	0.291[1]	0.01[3]
C	ASH FUSION TEMPERATURE			
	Initial deformation temperature	°C	820[1]	1200[2]
	Softening temperature	°C	1060[1]	1500[2]
	Hemispherical temperature	°C	1150[1]	1650[2]
	Fliud temperature	°C	1220[1]	1700[2]

[1] EUROFINS Umwelt Ost GmbH (Lab test on 15th October to 23rd October 2013)

[2] Skotland, 2011

[3] Friedrich Biedermann

Similar to the calorific value of the ash, softening temperatures can be estimated approximately from the substance of the relevant elements. Ca, K and Mg content in fuels are crucial in determining the softening point, where Ca content influence the higher softening point and K and Mg shows the contrary effect. An approximate estimation of melting point, softening point and flowing point in °C, where K, Ca and Mg are given in percentage of dry fuel mass by the equations, according to (Kaltschmitt *et al.*, 2001).

$$T_{SB} = 1159 - 58.7\,K + 237.9\,Ca - 743.8\,Mg \quad (1)$$

$$T_{EP} = 1172 - 53.9\,K + 252.7\,Ca - 788.4\,Mg \quad (2)$$

$$T_{FP} = 1369 - 43.4\,K + 192.7\,Ca - 743.8\,Mg \quad (3)$$

where:

T_{SB} Initial deformation temperature

T_{EP} softening point

T_{FP} Hemispherical temperature

Therefore from the above equations, the initial information, softening point and hemispherical temperature for EFB pellets can be determined through equations 1,2 and 3, taking the value from Table 1

$$
\begin{aligned}
T_{SB} &= 1159 - 58.7\,(1.21 \times 10^{-3}) + 237.9\ 3.72 \times 10^{-4}) - 743.8(1.65 \times 10^{-4}) \\
&= 1158.89\ ^\circ C
\end{aligned}
$$

$$
\begin{aligned}
T_{EP} &= 1172 - 53.9\,(1.21 \times 10^{-3}) + 252.7\ 3.72 \times 10^{-4}) - 788.4\ 1.65 \times 10^{-4}) \\
&= 1171.89\ ^\circ C
\end{aligned}
$$

$$
\begin{aligned}
T_{FP} &= 1369 - 43.4\,(1.21 \times 10^{-3}) + 192.7\ \ 3.72 \times 10^{-4}) - 743.81.65 \times 10^{-4}) \\
&= 1368.89\ ^\circ C
\end{aligned}
$$

Lower process temperatures in minimizing slag formation

To avoid slag formation, the gasification may operate at lower temperature, below the softening temperature (Lahijani *et al.*, 2011). Lahijani and Zainal, investigated EFB gasification in a pilot-scale air-blown fluidized bed reactor. In this study, it is found a bed agglomeration formation at temperatures exceeding 850 °C, and it is suggested that the gasification shall not be carried out at more than 850 °C (Lahijani *et al.*, 2011).

Another research conducted by Bui *et al.* (Bui *et al.*, 2002), suggested improvement that can be achieved by lowering the oxidation temperature. Particularly the hot spot temperature has to be lowered down below the ash melting point. However, this would affect the gas yield, increase the amount of CH_4 and CmHn which at the same time may increase the tar and benzene quantity which has been experienced by SWRO.

Use of Ca-based additives in minimizing slag formation

Apart from adjusting the operational temperature, another solution is by adding additive such as CaO to increase the melting point of the feedstock by compensating the lowering

abilities of the K (Kaltschmitt *et al.*, 2001). A research by Dong Energy and Vattenfall has suggested for additive addition of 3 - 5 wt% into the fuel (Biedermann, 2005) to increase the softening point temperature. This corresponds to a mixing ratio of around 1:1 of additive and fuel ash, found for European wood types, which seems to be the general minimum amount of additives that should be added. A research by M. Öhman *et al.*, (Skotland, 2011), has found that an additive amount of 0.5 wt% d.b. (dry base) of limestone $CaCO_3$, decreased the slagging drastically for a problematic wood fuel at 1000 - 1100 °C burning.

The mass ratio can give a guide to the amount of additive required. The mass ratio of Ca and P to K and Na can be represented by the following equation

$$r = \frac{(Ca + P)}{(K + Na)} \qquad (4)$$

If the value is less than one, this relates to the requirement of additive to increase the softening point. The purpose of adding phosphorous P in addition to calcium Ca is to result in crystalline phases with a higher melting temperature (Skotland, 2011). The following are the calculations of the existing ratio r0 and the ratio r1 with additive for the sample of EFB pellets using equation (4):

With data from Table 1:

Weight of (Ca + P)
$$= 3720+907 \text{ mg/kg d.b}$$
$$= 4627 \text{ mg/kg d.b}$$

Weight of (K + Na)
$$= 12100+481 \text{ mg/kg d.b}$$
$$= 12,581 \text{ mg/kg d.b}$$

Approximate Ratio

$$r_0 = \frac{4627 \dfrac{mg}{kg} d.b}{12,581 \dfrac{mg}{kg} d.b}$$
$$= 0.36 \text{ or } 9{:}25$$

$r_0 = 9{:}25 = 0.36$, the value is less than 1 which means the existing properties of EFB pellet will require additive to reduce the agglomeration problem. From the above calculation, an amount of 23 % of CaO should be added to increase the ratio to 1, taking into account that it will also increase the ash content of the fuel.

MATERIALS AND METHODS

700 kg of EFB pellets (Figure 1) were delivered from Malaysia to Rosenheim, Germany by sea freight. The delivery cost was funded by SIRIM and the material was sponsored by a Malaysian supplier, Detik Aturan Sdn. Bhd.

Figure 1. *EFB Pellets delivered from Malaysia to Rosenheim, Germany*

The tests have been conducted using fixed-bed reactor/gasifier PGW150, a fully operational gasifier designed and constructed by SWRO. This model commonly used European woodchips as a feedstock with very low ash content. Thus the design has not been equipped with an ash removal mechanism inside the reactor as shown in the Figure 2 below.
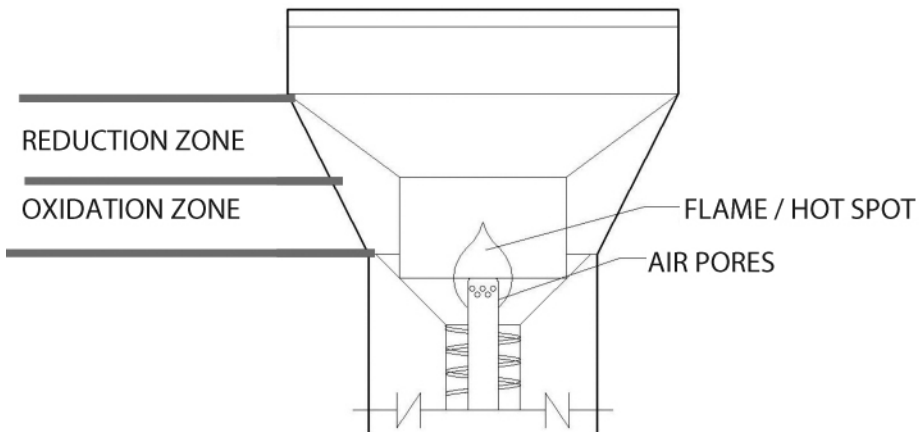
Figure 2. *Schematic cross section of the reactor.*

The char from the pyrolysis chamber is transported upwards by a screw conveyor, which also acts as an air inlet for oxidation. A thermo sensor is located in various places inside the gasifier and is connected to the monitoring equipment.
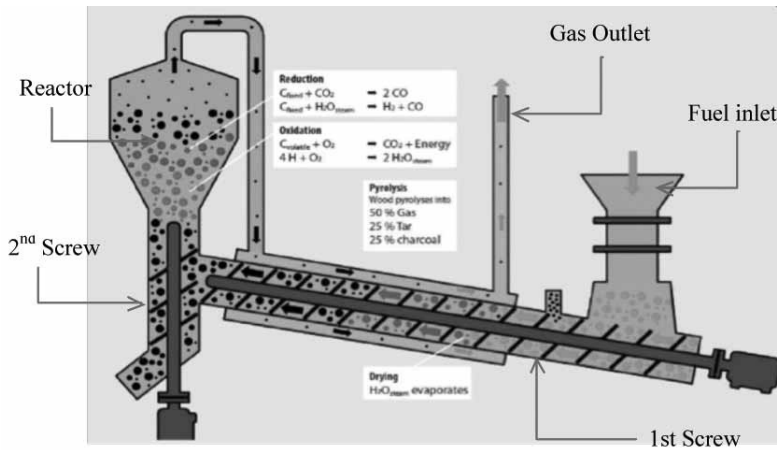
Figure 3. *Schematic cross section of fixed bed gasifier in SWRO.*

Gasification in SWRO commonly used spruce wood chip as fuel. Table 2 shows, that there are massive differences between EFB pellets and wood chips properties particularly in terms of ash content. EFB pellets contain 7 % of ashes while woodchip with less than 0.1 %. This is contributed by the fact that EFB pellets have a huge amount of K, being existent as K_2O, which is more than factor 30 higher than in spruce wood chips, as shown in Table 4 (see appendix). This element influences slag forming especially at high temperature (Williams *et al.*, 2007).

Table 2. Result from External lab test Wessling GmbH (Lab test carried out on 23 Sept 2013)

No.	OVEN DRY WEIGHT	UNIT	13-126712-01 EFB pellets	13-126712-02 Wood chips
1.	Moisture analysis	w%	1.7	0.5
2.	Rough humidity (b. 40 °C)	w%	5.9	
3.	Ash content (815 °C)	w%	7	<0.1
4.	Ash content (550 °C)	w%	7.9	0.2
5.	Cl	w%	0.29	0.02
6.	C	w%	45.1	49.4
7.	N	w%	0.61	0.09
8.	H	w%	5.8	6.6
9.	O (calculated)	w%	41.3	43.9
10.	S	w%	0.12	0.02
11.	$h_o(v)$ Higher heating value	w%	17,910	19,450
12.	$h_u(p)$ Lower heating value	w%	16,640	18,020

For the test with additive of Ca, the pellets are sprayed with a small amount of water to maximise the effective amount of additive sticking onto the pellet surface, well knowing, that mixing of EFB raw material and additive before pelletizing would be a better procedure. The amount of additive was chosen wisely, too much additive will result a non-stick additive to the pellet surface while less additive will not give a significant result. Therefore a pre-mix test was conducted, and an amount of 5 % was selected.

With 5 % additive, the new ratio can be estimated using equation 5;

$$= \frac{\text{w\% of Ca in additive} * \text{M\% of Ca from CaO+existing w\% of Ca}}{\text{New total w\%}} \qquad (5)$$

$$= \frac{0.05 \times 71.5\% + 0.0568}{1.05}$$

$$= 8.8\ \%$$

where 71.5 % is the correction factor from CaO to Ca (M % of Ca in CaO)

Therefore the new ratio r_1 =

$$= \frac{\text{New w \% of Ca+existing w \% of P}}{\text{w\% of K and Na}}$$

$$= \frac{0.088 + 0.0138}{19.20}$$

$$0.5 \text{ or } 1:2$$

This ratio is still below value 1, and increases to 14 % (from $r_0 = 0.36$ to $r_1 = 0.5$). It prolongs the gasification process, however the ash content is raised from 5 % to 13 %. From the above calculation, an addition of 23 wt% of CaO to EFB d.b. will increase the ratio to 1 and thus will reduce the agglomeration problem but then increase the ash content.

The EFB gasification test was carried out with a certain mixture of local wood chip from spruce under the advice from the engineers and plant operator. This is considered as it is well known that EFB contains a high amount of K_2O and the risk of agglomeration is highly expected. Several tests were carried out at conditions stated in Table 3.

Table 3. Type of test on EFB pellet gasification

TEST	EFB	WOODCHIP	NOTE
1	33%	67%	in PGW150
2	33%	67%	with CaO additive in in PGW150

Gasification test on EFB Pellet

The gasifier unit were heated up initially using hot air blower. The heating up was carried out with 100 % wood chips for several hours before the fuel was changed to the feedstock mixture. Prior to mixing, the moisture level of both type of feedstock is checked using humimeter. The feedstock mixture was passed into the feeder manually at approximately 900 °C, a desired oxidation temperature.

Test 1

The test was carried out with 33 % of EFB pellets and 67 % of spruce wood chip. The rest of the procedures are as stated as in general operation methodology.

Test 2

The test was carried out with 33 % of EFB pellets but with addition of CaO (4 %-5 % of EFB pellets quantity) and 67 % of spruce wood chip. The pellets were mixed with additive prior to mixing with spruce woodchip.

RESULTS AND DISCUSSION

Gasification Test on Palm Oil EFB Pellet (Test 1)

The gasifier was fired up at 7.20 am with wood chips before gasification stages approximately after 3 hours. Maximum temperature was recorded at 1172 °C at the middle of the reactor. Average gas yield was recorded at 2.6 m^3 /kg and CH_4 was recorded at absolutely 2.60 vol.%, higher compared to normal wood chips at 1.59 vol. %. After about 2 ½ hours of gasification, some pressure drop was experienced and the gas yields were equally reduced. Results are shown as in Figures 5 and 6.

The gasifier was shut down overnight to be cooled down. The next day an endoscope inspection was carried out and it was found that the pores/holes for air intake were clogged by a layer of molten ash/slag (Figure 4).
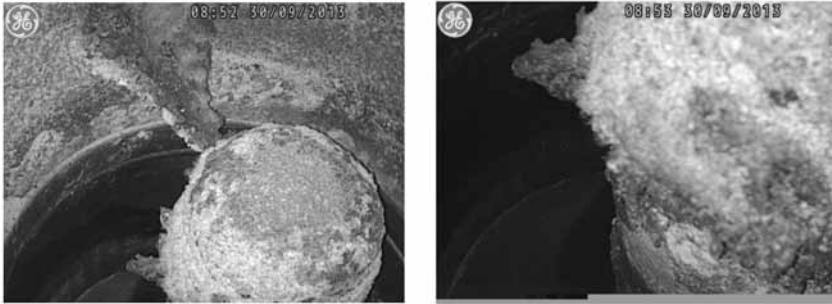
Figure 4. *Slag formation shutting the air pores at the air supply rod (view from inside)*

Even with only approximately 3 hours gasification of the mixture (33 % EFB pellets and 67 % wood chip) a massive amount of slag is clogging the pores of the air intake. The clogging reduced the amount of air supply into the oxidation zone and thus the production of gas is reduced.

The melting of the ash occurred at an oxidation temperature of 1020 °C as recorded while based from calculation, the softening is at 1368.89 °C. This may happen since the temperature sensors is located behind a concrete casing inside the reactor, protecting it from the heat source directly and thus the exact softening temperature could not be measured.
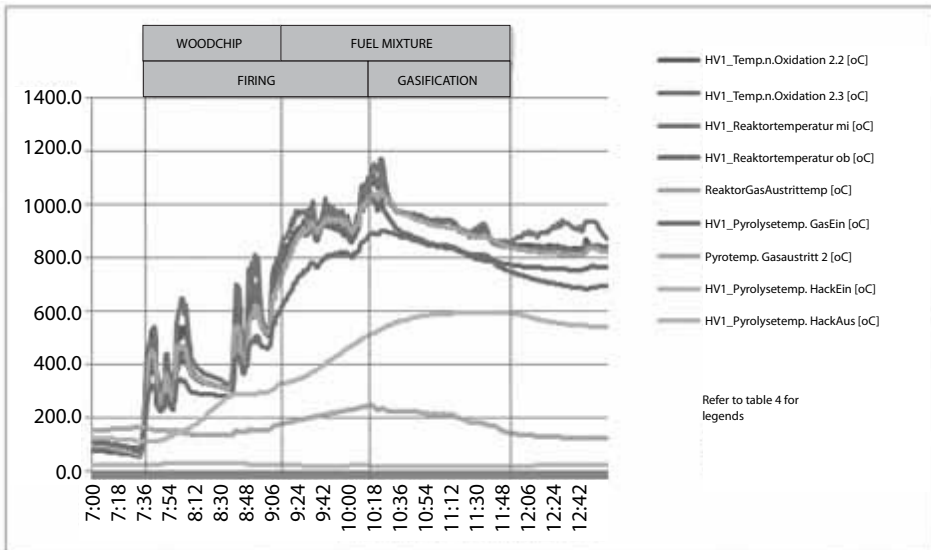

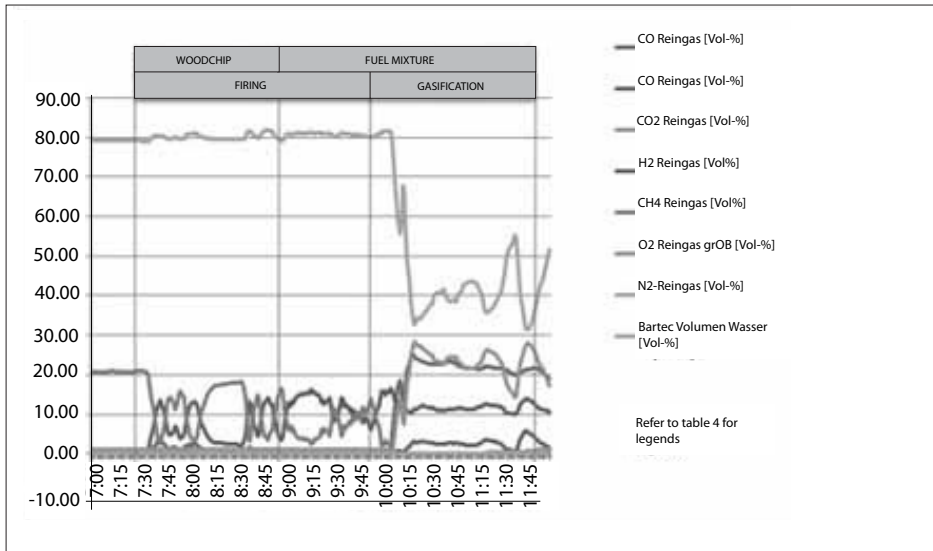**Figure 5.** *Temperature vs time during test 1 on 27th September 2013*

Figure 6. *Gas composition vs time during test 1 on 27th September 2013*

Gasification Test on Palm Oil EFB Pellet (Test 2)

Firing started at 8 am until 10.40 am. The 1st fed of the feedstock mixture began at 10.20 am. The feedstock was prepared and fed into the gasifier manually. A total of 23.15 kg of EFB pellets with 0.93 kg of CaO mixed with 46.3 kg of wood chips was used for the 1st day test. The feedstock mixture showed a promising result with constant pattern of gas composition and production. The gas produced was channelled to a 10 kW gas engine to analyse the gas performance. The amount of CH_4 is slightly higher compared to normal gasification with wood chips.

The 1st day test lasted for approximately 5 hours and at 4.00 pm, in which the gasifier was switched to normal wood chips for all night gasification. Figures 7 and 8 show the process and data reading on temperature and gas composition during the gasification of the feedstock mixture. Steady state was achieved approximately at 11.20 am, after ½ hour of gasification. During the steady state, the maximum temperature was recorded at 1106 °C at the middle of the reactor. Average gas yield was recorded at 2.98 m³/kg as demonstrated in Figures 5 and 6.
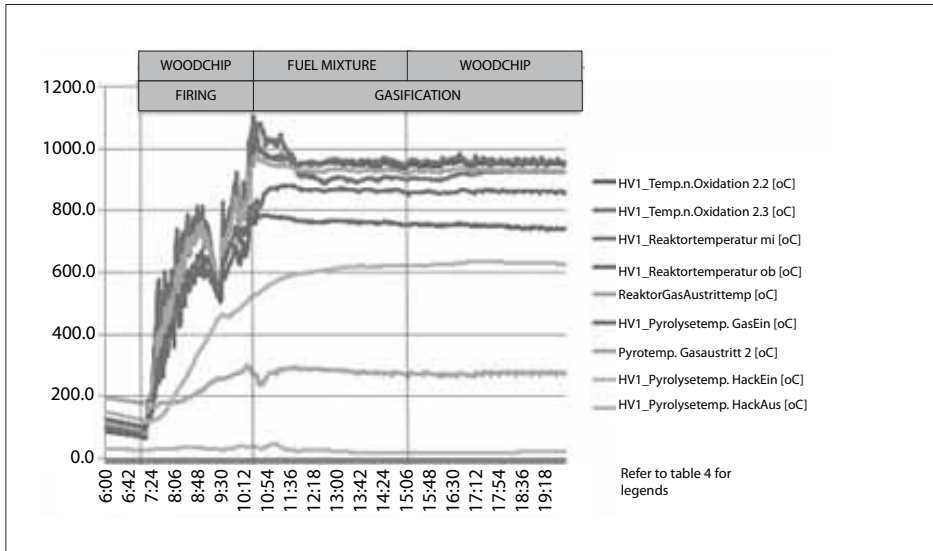
Figure 7. *Temperature vs time during test 3.1 on 9th October 2013*
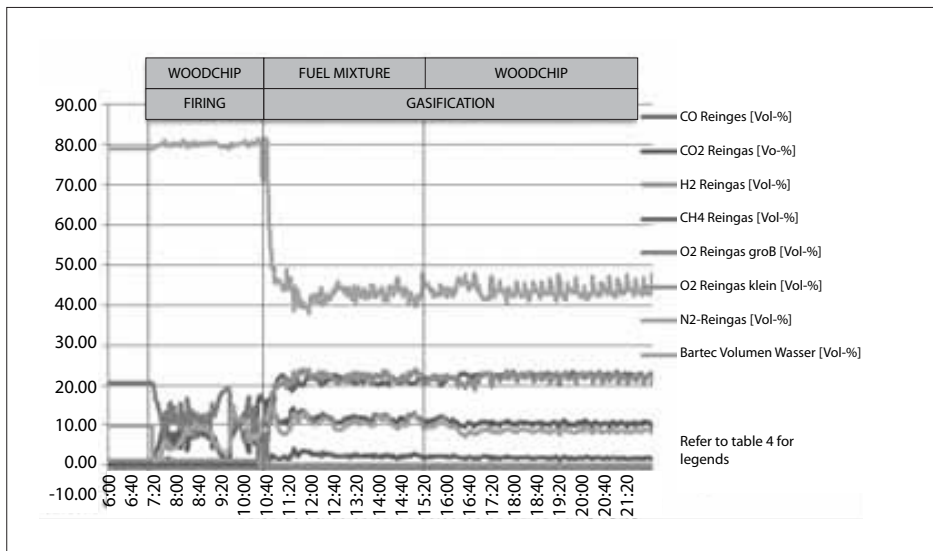

Figure 8. *Gas composition during test 3.1 on 9th October 2013*

Test 2 on day 2 was resumed on the next day (10th October 2013) with the 1st fed of the feedstock mixture began approximately at 8.33 am. Similar process and procedure were applied. The gasifier was left running continuously from the previous day for the whole night with wood chips, and thus there was no need for firing up.
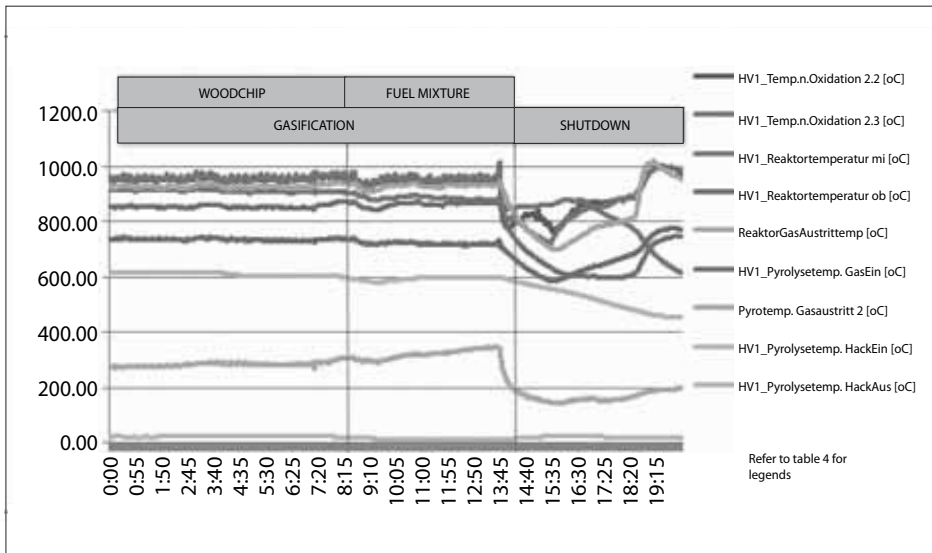
Figure 9. *Temperature vs time during test 3 day 2 on 10th October 2013*
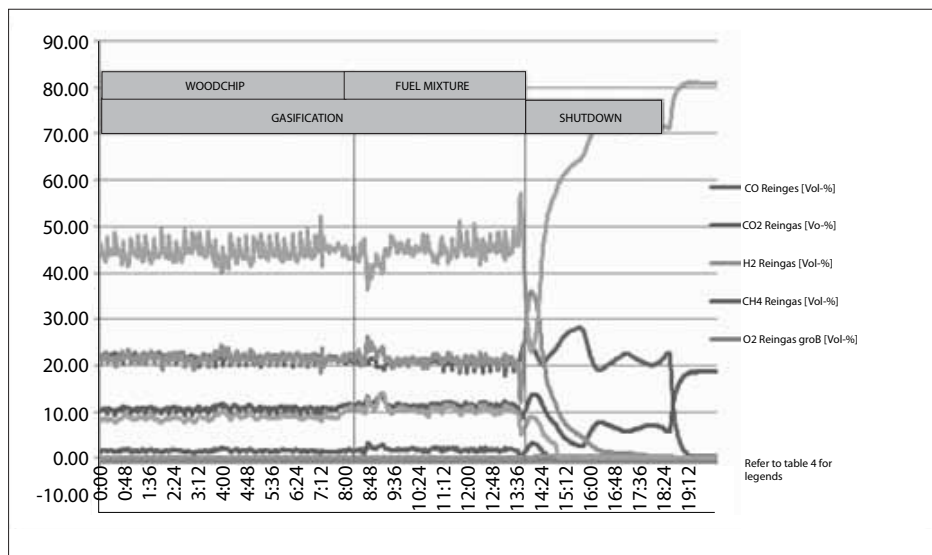

Figure 10. *Gas composition vs time during test 3.2 on 10th October 2013*

During the steady state, the maximum temperature recorded was 1015.5 °C at the middle of the reactor. The average gas yield was recorded at 2.96 m³/kg and the amount of CH_4 is slightly higher compared to normal gasification with wood chips. Cold gas efficiency was recorded at 83.3 % and the calorific value of the feed stock mixture is 5.30 MJ/m³. The gas analysis at the exhaust of the gas engines also shows a higher amount of CO_2 compared to wood chips while the average value of Benzol was recorded at 1573 mg/m³.

After approximately 10 hours of gasification of the EFB pellet mixture with additional CaO in test 2, the gasification process was hampered as a result of the agglomeration of the molten ash at the air pores which was blocking the incoming supply of air for oxidation, (Figure 11). During the endoscope inspection, it was found that the whole air pores were completely blocked by agglomeration as shown in Figures 11 and 12.
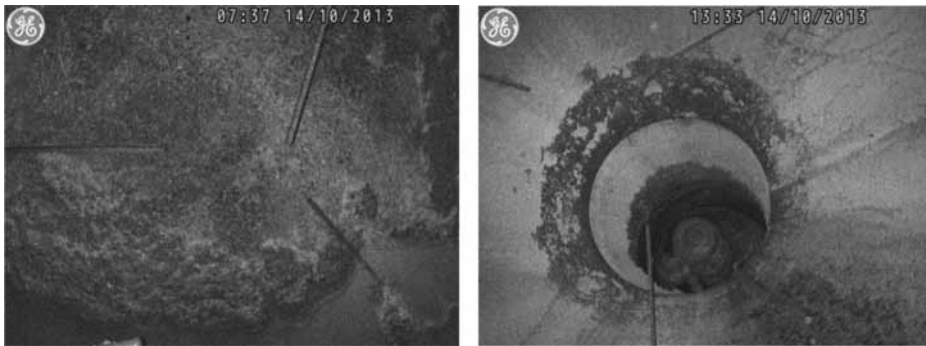

Figure 11. *Slag formation inside the reactor at the end of test 2 day 2 (view from inside, top peek hole). Left plate shows before cleaning, and right plate after cleaning*
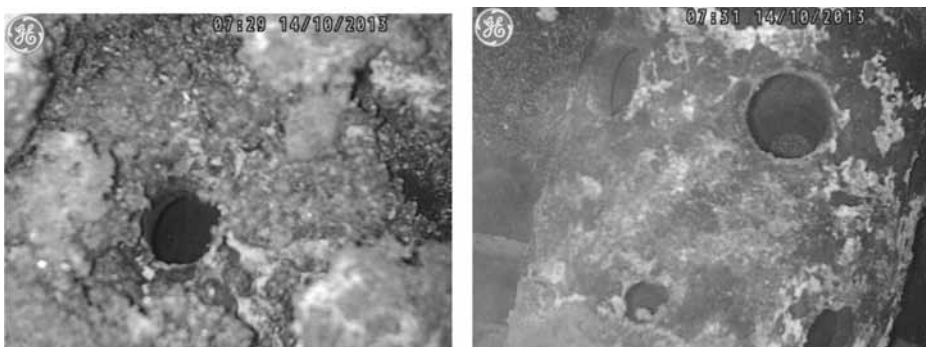

Figure 12. *Slag formation at the air supply holes (view from inside, side peek hole). Left plate shows before cleaning, and right plate after cleaning*

Based on the Figures 11 and 12, the amount of hardened molten slag is higher in test 2 compared with test 1. The slag found in test 2 was only around the hot spot (end of conveyor rod with air pores), in test 2, (with addition of additive) the amount of slag was massive, filling in the whole bottom part of the reactor. This material was not a sintered agglomerate, but a hardened molten slag/agglomerate vitrified together with ashes.

DISCUSSION

The biggest challenge in EFB gasification is the feedstock itself. Given the state of chemical characteristic of the feedstock, an unwanted ashes and residues which will affect the gasification in gasifiers as in SWRO. Three different possibilities may solve the problem:

Premixing of EFB and Additive

From the experimental results, addition of additive has increased the softening point thus making the gasification of EFB pellets possible. It is suggested that the premixing of additives and EFB should be carried out prior to pelletizing process to achieve optimum distribution of additives on the pellets. Since the ash content of EFB pellet is naturally high, it is suggested that only a small amount of additive to be added, so that the ash content can be kept as minimum as possible.

Leaching of EFB before pelletizing

However, by just using additive is not sufficient to solve the problem. A massive amount of additive will be needed and this will result in high ash content in the fuel. Therefore the amount of softening point elements has to be reduced so that only a minimum amount of additive has to be added to avoid increasing the ash content of the fuels (Sulaiman, 2013). This can be done in pre-treatment by washing the raw material to remove as much as possible the amount of water dissolving components such as K and Cl. Then the dried raw material should be mixed with a certain amount of additive before it goes into the palletisation process. A further research is necessary to observe the positive effect of this method in the future and to find out the boundary conditions for economical calculations.

Adjusting reactor design for hot spot reduction

Another solution is probably by making a few adjustments to the geometrical design of the gasifier especially in the reactor with regards to hot spots. The pores for air supply must not be in direct contact with the char and thus, hot spots would not melt the ashes. In addition, it ensures a continuous flow of the supply air for the oxidation.

The reactor shall also be equipped with an ash removing mechanism so that the ash built up inside in the reactor can be removed consequently during the gasification. Optimum mechanism is needed for fuels that will use additive or fuels with higher ash content. Similarly, another way is by having an equal distribution of heat inside the reactor thus eliminating the hot spots. This means, the whole reactor has a high temperature being rather constant, high enough for gasification and tar reduction, but without any single point of extreme temperature. It is still essential to ensure the temperature is well below the softening point so that no agglomerations occur.

CONCLUSION

With the current technology of gasification in SWRO, a gasification of 100 % untreated EFB pellet is almost impossible to be carried out continuously in long hours. EFB contains a high amount of ashes and high amount of elements that contribute to low softening point of the fuel. This leads to lower softening point which leads to agglomeration problem. The pellets have to be pre-treated by reducing the low softening point elements and by adding additive. The current design of the gasifier which was designed for lower ash content fuels requires major improvement. The presence of the hot spot near the char entry and poor mechanism to draw out the ash from the reactor may give hindrance to smooth gasification process.

ACKNOWLEDGMENT

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APPENDIX

Table 4. Legends for result charts:

BIL	LABEL (GERMAN)	DESCRIPTION
1	CO Analyse	CO analysisi
2	CO2 Analyse	CO2 analysis
3	H2 Analyse	H2 analysis
4	CH4 Analyse	CH4 Analysis
5	O2/1 Analyse	O2 analysis
6	O2/2 Analyse	O2 analysis
7	N2 berechnet	N2 analysis
8	Feuchte Vol%	Moisture vol%
9	Temp mittelwert	Average temperature
10	Temp Oxidation 2.4	Oxidation Temp 2.4
11	Temp Oxidation 2.3	Oxidation Temp 2.3
12	Temp Oxidation 2.2	Oxidation Temp 2.2
13	Temp Oxidation 2.1	Oxidation Temp 2.1
14	vor Oxidation 2	Before Oxidation 2
15	vor Oxidation	Before Oxidation 2
16	T.gas Austritt	Temp hot gas (ext)
17	Temp oben	Temp (top)
18	Temp mitte	Temp (middle)
19	Reaktor druck	Reactor pressure
20	Pyrolyse Austr	Pyrolysis exit (wood)
21	Temp v. reactor	Temp before reactor
22	Pyrolyse Eintritt	Temperature Pyrolysis in (hot gas)
23	Pyrolyse Austritt	Temperature Pyrolysis out (hot gas)
24	Pyrolyse Eintritt	Temperature Pyrolysis in (wood)
25	Decke 1	Temperature (hull)
26	Decke 2	Temperature (hull)
27	Decke 3	Temperature (hull)
28	Lufttemperatur	Hot air temperature for oxidation
29	Aschenbehalter	Ash container temperature
30	Oxidationsluft	Air flow rate for oxidation
31	Druck	Pressure before pyrolysis
32	Forderschnecke 2	Screw conveyor for reactor
33	FU Spannung	Motor voltage
34	400FU Strom	Motor current
35	400FU Lestung	Motor poer
36	Gewicht	Weight