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# 배치공정에서 왕겨가스화 특성

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# Gasification Characteristics of Rice Husks in Batch Operation

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**Abstract**

An experiment was conducted in order to investigate gasification characteristics of rice husks in a fixed bed, which was a pre-step to design a continuous gasification system. Two air supply levels for gasification were chosen and their effects on the producer gas amount and producer gas composition were discussed. The main components of the producer gas were CO, $CO_2$, $O_2$, $H_2$ and THC (Total HydroCarbon). As airflow rate decreased, more producer gas was produced. The peak amount of CO, $H_2$ and THC were 28%, 7.5% and 0.68% in volume when constant airflow rate of 3.36 $m^3/s$ was used in the batch operation. About 4.5 kg of ash (9%) and condensed water including tars of 6 kg (11%) were produced from 50 kg rice husks in the gasification. Excluding the byproducts, all rice husks seemed to be transformed into producer gas. This gasification study was conducted prior to developing a continuous gasification system for biomass including agricultural byproducts.

**Keywords** : Gasification, Rice husks, Combustible gas

## 1. Introduction

About 16 to 18% of rice in weight transforms to rice husk during rice milling process in Rice Processing Complex (RPC) in Korea. About 1.5 million tons of rice husk is produced and most of them are consumed in various places for; moisture absorbent in animal pen floors, bed soil for young rice seedlings or strawberry seedlings, and melting furnaces in iron mills. Some RPCs contract with distributors for disposing of rice husk with small compensations. So far, rice husks are regarded as value zero commodity. However, recently some RPCs located in the big plain areas began to build rice husk treatment facilities where they produce rice husk carbon and extract rice husk pyrogallic acid, known as natural insecticide and expensive value added product, which are very valuable elements for maintaining environment friendly farming.

Though several attempts (Korea Energy Research Institute, 1980) were made to combust rice husks as fuel resource for boiler heating in domestic or abroad, no meaningful results were presented so far. Consequently, no rice husk combustion boiler has been adopted yet in large because of relatively cheap fossil fuels price and great amount of tar content in the rice husk combustion gas that can damage the interior of boilers. However, because of international $CO_2$ reduction agreement, attentions to biomass energy utilization technology development for fuel resource are increasing ever before. Rice husks are one of the readily available energy resources that could substitute some fraction of fossil fuels consumed in heating or power generation.

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Gasification is a process that converts carbonaceous materials into combustible gases, which occurs at temperature above 700℃ when the glowing coke is allowed to react with a gasification agent such as oxygen, air or steam. The coke is gradually broken down into gases such as CO, $CO_2$, and $H_2$. Pyrolysis is also a thermal process that initiates at around 230℃ without oxygen supply and the resulting pyrolysis gas consists mainly of tar, polycyclic aromatic hydrocarbons (PAH), methane ($CH_4$), steam and $CO_2$. Usually, complex reactions, both gasification and pyrolysis, are observed in the gasifier (Henriksen et al., 2006).

Unlike the low level of biomass utilization technology development situation in Korea, northern EU countries with abundant forest resources have made significant accomplishments in the area of biomass energy electric power generation through gasification or pyrolysis process. Henriksen et al. (2006) developed 75 kW class two-stage gasification system with wood chips, which is recently ready to be propagated. It is a down draft type gasification system producing combustible gases including CO, $H_2$, $CH_4$, $N_2$ and $CO_2$. Chungsangunsit et al. (2004) tried to utilize rice husks as fuel resource substituting for fossil fuels in order to generate electricity and assessed the impact of emission gases such as $CO_2$, $SO_2$, $NO_X$ and CO to environment. They suggested a need for improving the combustion efficiency of the biomass power plant.

The objective of this study was to investigate the characteristics of rice husk gasification process both by qualitatively and quantitatively by identifying the producer gas from a batch type gasifier filled with rice husks.

## 2. Materials and Methods

### A. The gasification system

Figure 1 shows the gasifier built for this study and was custom-made by the local incinerator manufacturer. Major components are furnace, fan, and loading gate.

Size of the gasifier is Φ1000×500~1000H, made of stainless steel. Inside of the gasifier is treated with fire bricks that can resist high temperature caused by rice husks combustion.

A fan (360 W, 220 V) with a damper adjuster was used to control airflow rate. Loading rice husks and removing ash were accomplished through the loading gate and the ash gate, respectively. Producer gas was discharged to atmosphere through the gas outlet. Figure 2 shows the gasification system

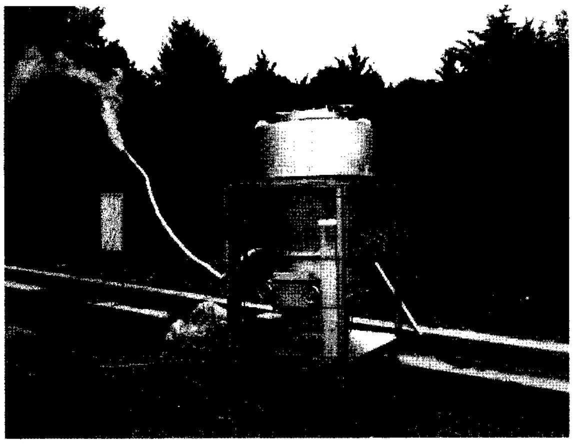

Fig. 1 The gasifier used for this experiment.

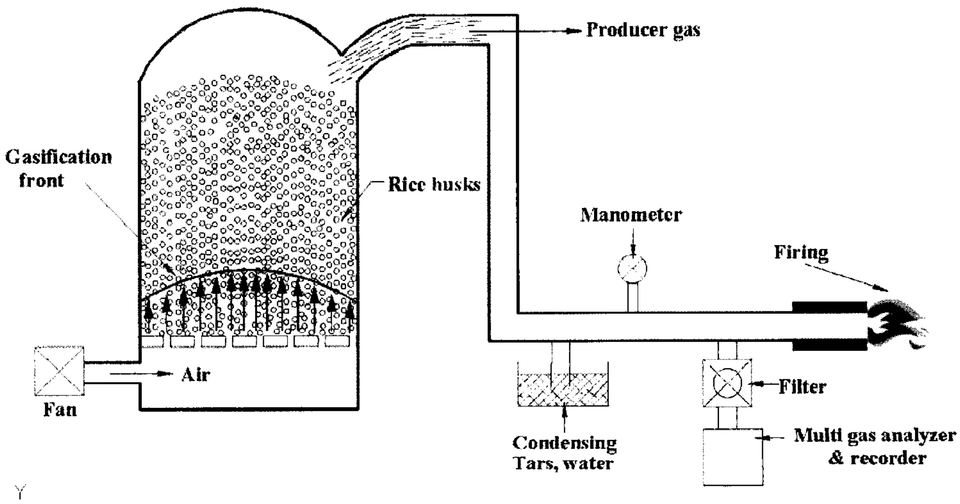


Fig. 2 Updraft gasification process adopted in this experiment.

adopted in this experiment, where the gasifier was updraft type. In a updraft type gasifier, air is supplied from bottom and producer gas outlet is located on the top. Ignition of rice husks was initiated by turning on the light oil burner, and once stable combustion was confirmed the burner was turned off so the gasification progressed by the combustion heat of rice husk itself.

## B. Real time multigas analyzer

In order to identify as well as quantify the combustion gas components, a multigas analyzer (A&D 9000 series, A&D system, ROK) and a recorder (mv200, Yokogawa, Japan) shown in Figure 3 was used, where major gases to be identified were $CO_2$, CO, $H_2$, $O_2$, and THC (total hydrocarbon). Measurement ranges and sensor types for the various gases were determined after several pretests and many consultations with the gas analyzer manufacturer.

The multigas anayzer can detect wide concentration ranges of producer gas; CO - 0 ~100%, $H_2$ - 0~10%, $CO_2$ - 0 ~ 30%, THC - 0~10,000 ppm. However, since the producer gas contained a lot of tars we had to filter the impurities with the water column before the producer gas entering the multigas analyzer.

## C. Data collection procedure

Fifty kilograms of rice husks, 10.8% w.b., was loaded into the gasifier. With turning on the light oil burner, the gas gasifier was started to operate and when the gasification process reached stable state, which was judged by recognizing constant temperature increasing inside the combustion cham-

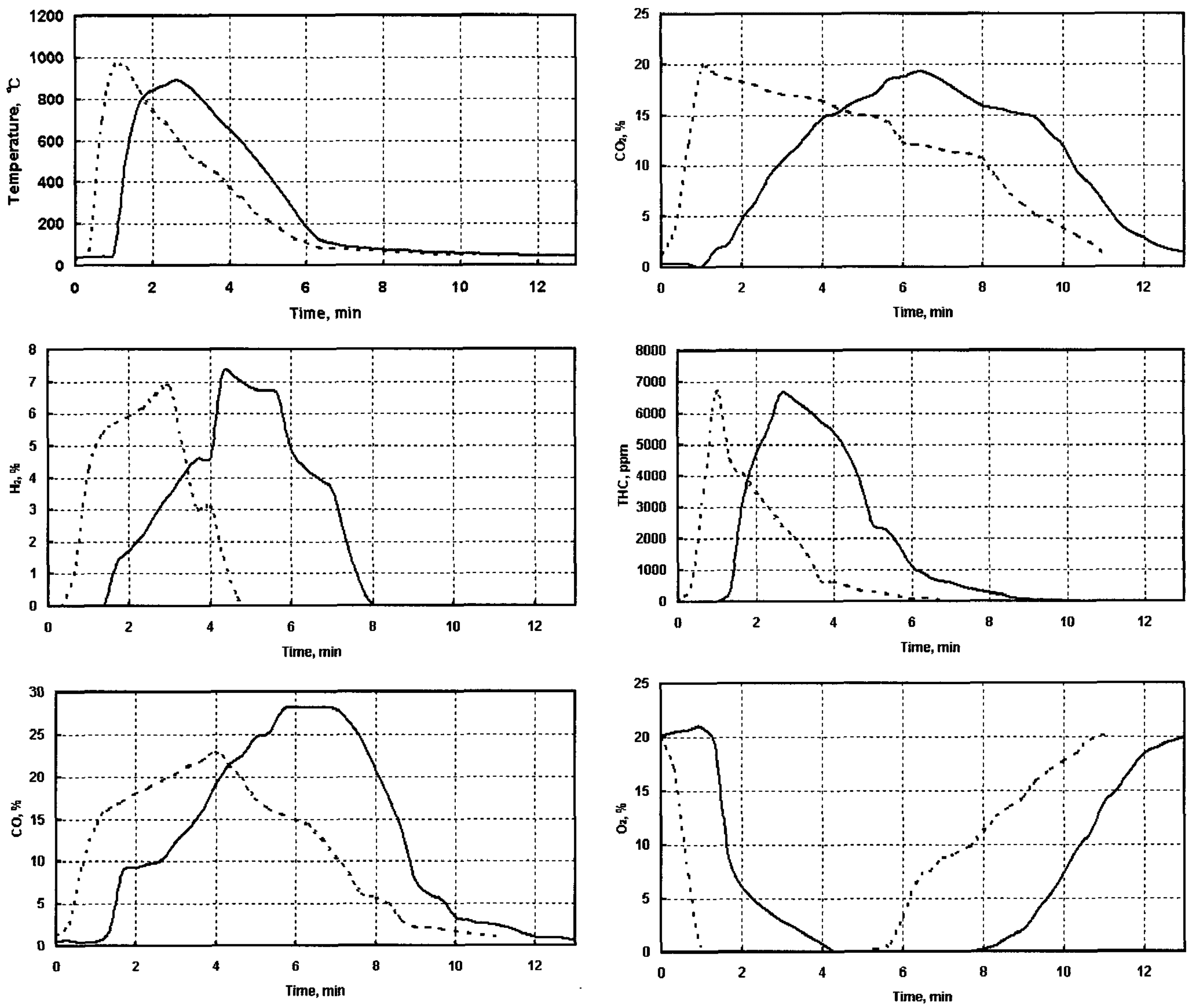


**Fig. 3** Changes in producer gas composition (····4.56 $m^3/s$, — 3.36 $m^3/s$).

ber, we turned off the light oil burner so that the gasification carried on by itself with its own combustion heat. Two airflow rates were chosen after finishing several pretests. Lower airflow rate, 3.36 $m^3/s$, was the minimum airflow rate the gasification could sustain, while the higher airflow rate, 4.56 $m^3/s$, was set for the comparison. After setting, the airflow rate was not changed during one gasification process. When the gasification process reached steady state, the suction pump in the multigas analyzer was operated and drew producer gases. Producer gases were sampled every 10 minutes in order to avoid the frequent filter blockages caused by excessive tars in the producer gas. To monitor temperature changes inside the gasifier, we have placed four K type thermocouples with 20 cm interval from the bottom to the top and stored the temperature data.

## 3. Results and Discussion

### A. Changes in producer gas composition

In the typical complete combustion of fossil fuels, which are composed of carbon and hydrogen compound, $CO_2$ and $H_2O$ are the major products except small amount of sulfuric oxides and nitrogen oxides. However, in this investigation we provided far less oxygen for normal combustion in order to achieve maximization of combustible gases such as CO, $H_2$, THC. Producer gas pattern was shown up as we anticipated (Fig. 3). As a whole, the lower airflow rate of 3.36 $m^3/s$ resulted in producing more combustible gases the area under the solid line in CO, THC, and $H_2$ plot than the higher airflow rate of 4.56 $m^3/s$. Perhaps it could be true that if we provided less airflow rate than 3.36 $m^3/s$, we probably could get more combustible gases, but then we could have some problems in maintaining the gasification process such as combustion interruption due to lack of air (oxygen). In general, more rapid gasification process was conducted in the higher airflow rate, the dotted line in the Figure 3. Total length of time for the gasification processes were about 14 hours, however, combustible gases including $H_2$, CO and THC were not produced after 11 hours. But, $CO_2$ was incessantly produced during the whole gasification processes.

### B. Combustible gases

One of the objectives was to quantify combustible gas production from the rice husk gasification. Expected combustible gases were CO, $H_2$ and THC, and individual gas proportions were quite different during the gasification processes. With airflow rate of 3.36 $m^3/s$, the peak amount of CO was the greatest being 28%, followed by $H_2$, 7.5%, and THC amount was less than 1% (6,900 ppm). On the other hand, at airflow rate of 4.56 $m^3/s$, the peak amount of CO was 23%, followed by $H_2$, 6.9%, and THC amount was 6,900 ppm. According to the study conducted by Henriksen et al. (2006) on the gasification of wood chips, 32% $H_2$, 15% CO, 2% $CH_4$ were produced in the continuous partial pyrolysis operation. These differences seem to come from the differences in biomass resources and gasification process. Average temperature inside the gasifier was between 300 to 400℃ during the gasification process, though the peak temperature were 950℃ and 900℃, respectively. And, significant temperature differences (400℃ ~700℃ at 6 hours since the gasification started) of the were existed between the combustion zone and ash layer. To confirm combustion capability of the combustible gases, we set fire to the gases as shown in Figure 4. It seemed the combustible gases has some similar fuel qualities like that of LPG and LNG.

**Fig. 4** Firing the combustible gases.

### C. Mass balance in the rice husk gasification

When fifty kilograms of rice husks was gasified with airflow rate of 3.36 $m^3/s$, about 4.5 kg of ash (9%) and 5.9 kg of water including tars (11%) were produced, and with airflow rate of 4.56 $m^3/s$, 3 kg ash (6%) and 4.12 kg of water including tars (8.2%) were produced. The rests were likely to be transformed to gases. The lower the airflow rate was, the more the byproducts were produced.

## 4. Conclusions

A batch type gasification system was designed for rice husks and tested for airflow rate effects on the amount of combustible gases production and their byproducts quantity. Expected combustible gases were CO, $H_2$ and THC, and individual gas proportions were quite different during the gasification processes for two airflow rates. With airflow rate of 3.36 $m^3/s$, CO was the greatest amount reached at 28% at the peak and followed by $H_2$, 7.5%, and THC amount was less than 1%. When fifty kilograms of rice husks was gasified with airflow rate of 3.36 $m^3/s$, about 4.5 kg of ash (9%) and 5.9 kg of water including tars (11%) were produced, and with airflow rate of 4.56 $m^3/s$, 3 kg ash (6%) and 4.12 kg of water including tars (8.2%) were produced. The rests were likely to be transformed to gases. The information collected in this experiment will be very helpful to design a continuous feeding type gasifier.

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