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# 석탄과 바이오매스 혼합공급에 따른 가스화 특성 모사 연구

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# A Simulation Study on the Gasifier Performance in the Coal/Biomass Mixture

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**Keywords**: Co-gasification, Biomass, Simulation, ASPEN PLUS

**ABSTRACT**: A process flowsheet simulation model based on ASPEN PLUS was developed to investigate the effect of co-gasification of coal and rice husk on the gasifier performance and pollutant emissions in IGCC power plant. The analyses were done for an O2-blown, pulverized gasifier using coal and rice husk as feedstock, parameter employed the blending ratio of rice husk in coal were investigated. From the simulation results, it was found that gaseous pollutant emissions were reduced substantially with the increase of the blending ratio of rice husk. An optimum range between 15% and 25% rice husk-to-coal ratio was found to be the optimum point in terms of gaseous pollutant emission per energy output for sulfur and nitrogen compounds.

## INTRODUCTION

Co-gasification of coal and biomass is an important area of exploration and is potentially a major option for the utilization of biomass if some of the technical, social, and supply problems can be overcome satisfactorily. In the presented investigation, rice husk was used as candidate feedstock for co-gasification with coal since it is one of the most important residues in terms of quantity associated with agricultural production. In Asia, rice husk is cheap, the source is abundant, and the energy content is relatively high compared to other agricultural sub-products[1]. The utilization of rice husk in the power plant can also provide a solution for waste disposal[2]. However, very few researches were focused on the characteristic in co-gasification of coal and rice husk in a pulverized coal combustion system[3], especially in gasification process of IGCC.

## METHODOLOGY

Simulation of co-gasification with rice husk and pulverized coal were conducted in the IGCC gasifier modeled with ASEPEN PLUS. Fig.1 shows the ASPEN PLUS flowsheet of gasification process fed with coal and biomass mixture.

From Fig.1, it can be seen that the co-gasification process in IGCC power plant contains fuel preparation and gasification processes. In the coal preparation, coal is crushed in size to 0.15cm and 100$\mu$m sequentially. The particle size of rice husk is also reduced to 100$\mu$m. Dried by hot $N_2$, the pulverized fuel is then routed to the gasifier where $N_2$ is an inertial transporting gas. The gasification process considered during the simulation is consisted of decomposition, making slag, gasification and raw gas separating process.

The ultimate and proximate analyses of coal and biomass were shown in Table 1 [4].

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Table 1 Proximate and Ultimate Analysis of Coal and Biomass

| Proximate analysis (%dry basis) | | | Ultimate analysis (%dry basis) | | |
|---|---|---|---|---|---|
| | Coal | Bio | | Coal | Bio |
| Mo | 14.60 | 25 | C | 67.08 | 36.57 |
| VM | 32.21 | 60.55 | H | 4.31 | 4.61 |
| FC | 57.70 | 16.02 | N | 0.66 | 0.73 |
| Ash | 10.09 | 18.93 | O | 19.26 | 39.04 |
| | | | S | 0.60 | 0.12 |

It can be seen that the carbon and sulfur contents in rice husk, which directly affect the performance of gasification, are different with the coal. To investigate the co-gasification characteristics, the simulation was conducted under different blending ratio of coal to rice husk.

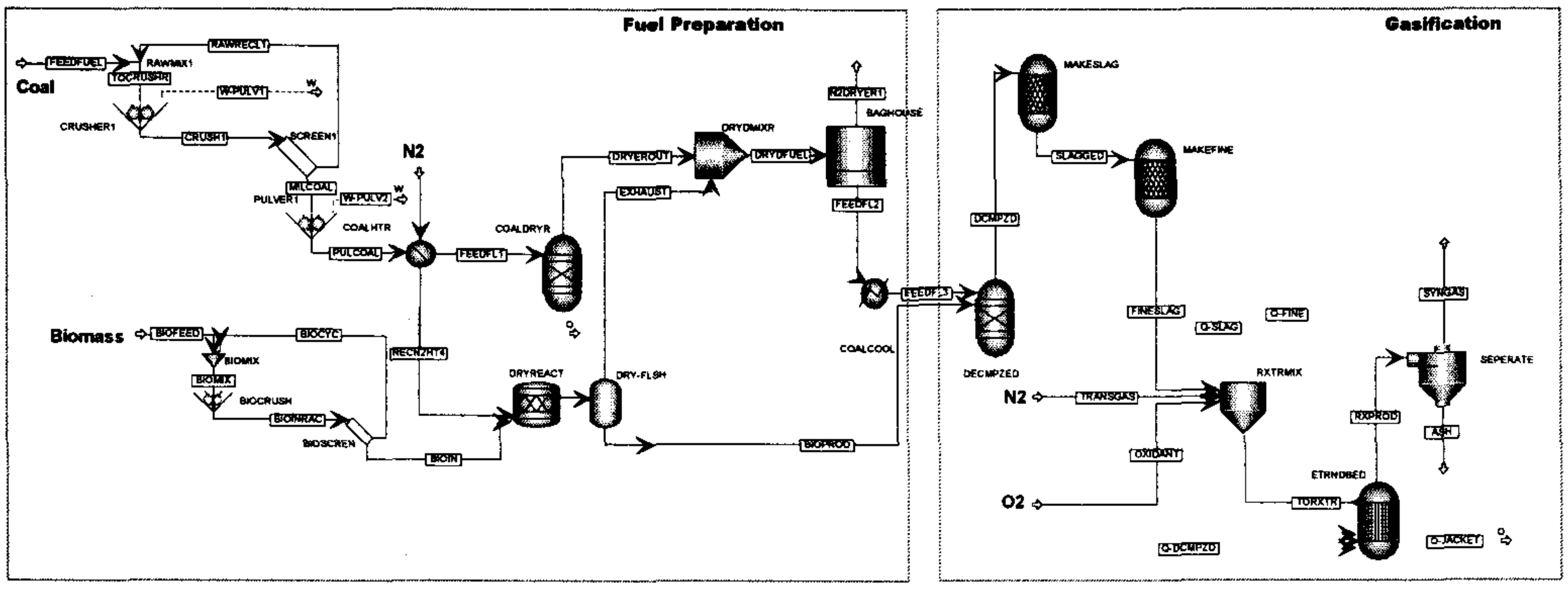


Fig.1 The ASPEN PLUS diagram of co-gasification of coal and rice husk for IGCC power plant

## RESULTS AND DISCUSSION

Rice husk has more moisture and volatiles than coal, which results in the total mass flow rate of solid residue reduced fleetly. Fig.2 shows the output steam of slag and ash varied with the blending ratio of rice husk in coal. From the Fig.2, it can be seen that the main contributor to the output residue is slag. With increasing the blending ratio of rice husk in coal, the mass flow of slag is sharply increased. It is because biomass has high oxygen content and ash content.

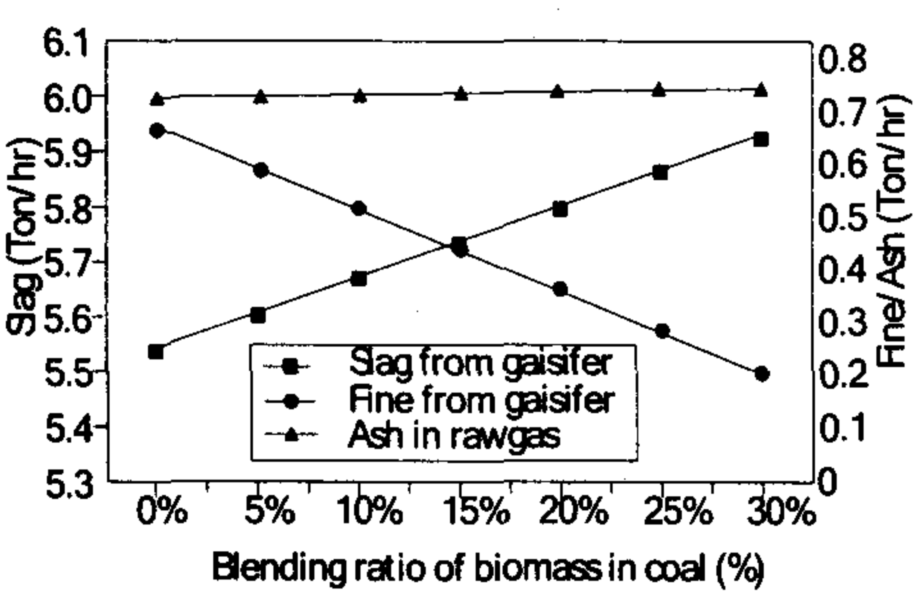


Fig.2 Mass flow rate of solid residue of gasification varied with the blending ratio of biomass in coal

Fig.3 shows the mole flow rate of component in the raw gas varied with the blending ratio of biomass in coal. It can be seen that the rice husk mixed with coal increased from 0% to 30%, the quantity of combustible content in the raw gas (CO, $H_2$ and $CH_4$) decreased about 6.5% and $CO_2$ had been increased 14.7% unhappily. Therefore, the heat value of raw gas will be decreased compared with the coal feestock. It should be concerned that the CO content, the reduction of CO was over 10% after blending 30% rice husk. This suggests that rice husk can enhance the completeness of the combustion process.

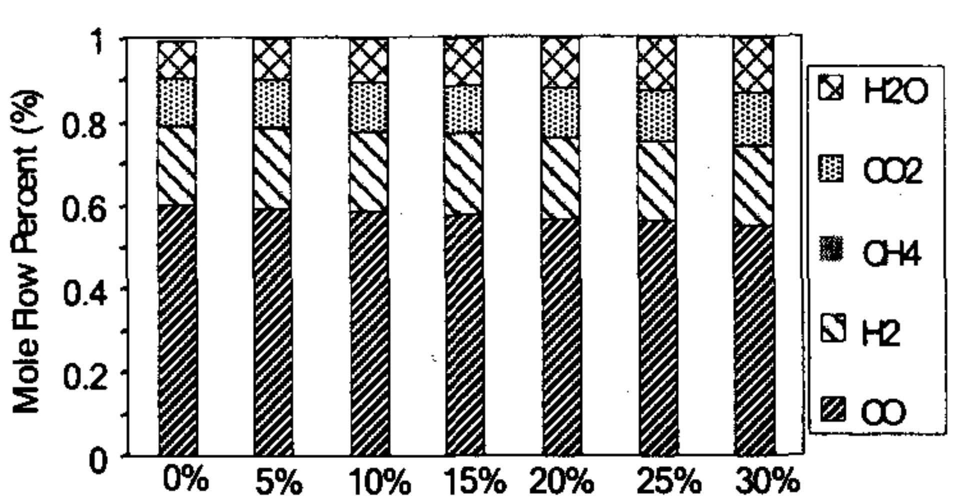


Fig.3 Composition of the raw gas varied with blending ratio of coal and rice husk

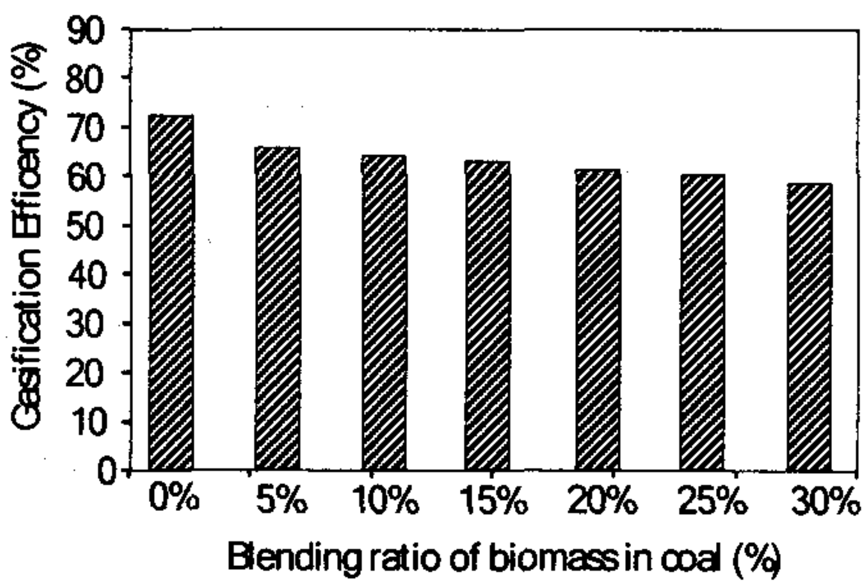


Fig.4 Gasification efficiency varied with blending ration of rice husk in coal

There are a number of different criteria that are frequently quoted for gasification process. The most commonly encountered are gasification efficiency (cold gas efficiency). The definition is:

$$GE = \frac{\text{Heat value in raw gas}}{\text{Heating value in feedstock}} \times 100\% \quad (1)$$

where the heating value in feedstock is on higher heating values (HHV) of coal and biomass[5]. Fig.4 shows the gasification efficiency changed with the blending ratio of rice husk in coal. It can be seen that, the gasifier efficiency fed with dried coal is 72%, mixed with 30% rice husk, it dropped to 60% approximately.

Fig. 5 shows the variation of sulfide emission ($H_2S$ plus COS in raw gas) with different blending ratio. About 20% of the sulfide emission was reduced after mixing 30% rice husk in coal. It can be explained that the sulfur content in coal was about five times of that in rice husk. The reduction of the sulfide emission can be attributed to the decrease in the overall sulfur content in the fuel.

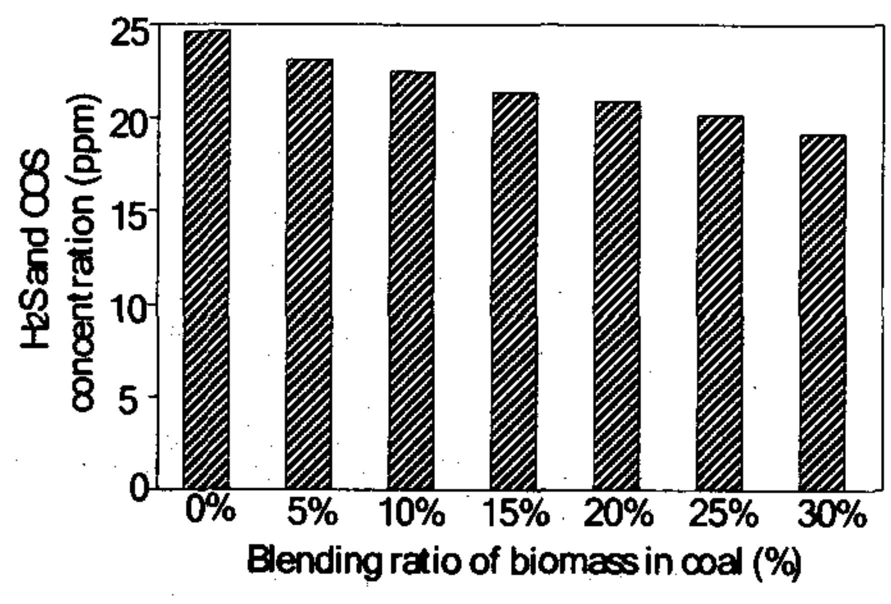


Fig.5 Sulfide ($H_2S$ and COS) emission from co-gasification of coal and rice husk

Fig. 6 shows the variation of the sulfide emission per energy in the raw gas with different blending ratios of rice husk in coal. The minimum sulfide emission per energy output was at the blending ratio of about 15%-25%, which is affected by the overall fuel sulfur content and gasifier performance.

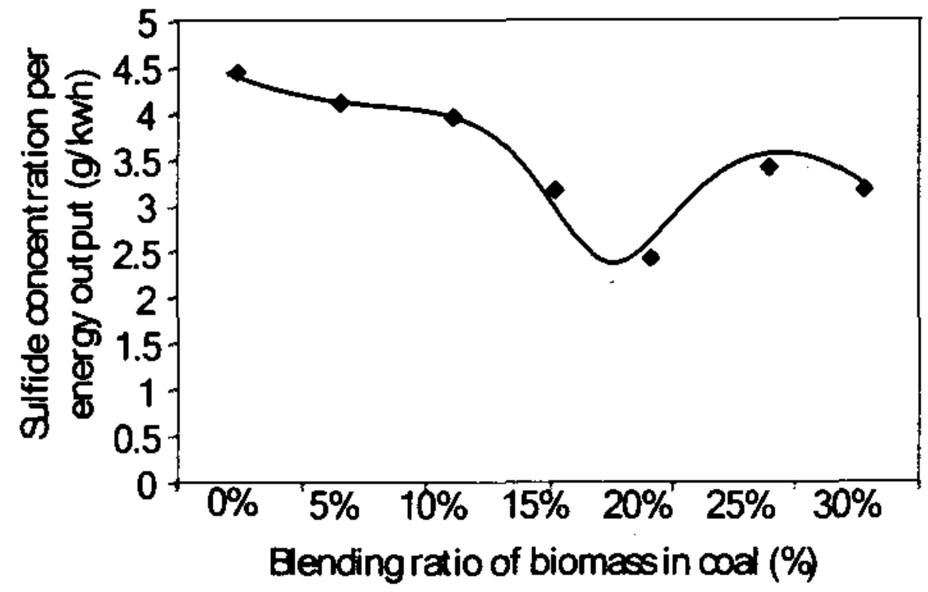


Fig.6 Sulfide emission per energy output from co-gasification of coal and rice husk

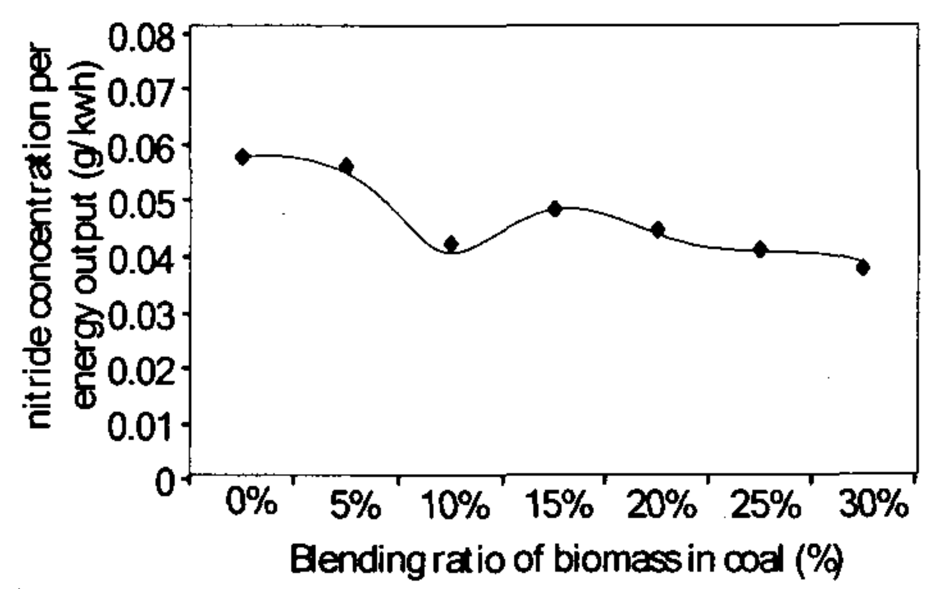


Fig.7 Nitride ($NH_3$) emission per energy output from co-gasification of coal and rice husk

Fig. 7 shows the variation of the $NH_3$ emission per energy output with different blending ratios of rice husk in coal. The minimum $NH_3$ emission per energy output was at the blending ratio of about 10%-30%, which is affected by the overall heating value of the fuel, gasification pressure and temperature.

## CONCLUSIONS

Co-gasification of coal and rice husk can be a practical and attractive approach to increase the using of renewable energy with reduction of green house emission. An ASPEN PLUS simulation model was created to investigate the performance of co-gasification of coal and rice husk in IGCC.

From the results, it can be concluded:

(1) After blending 30% rice husk, the reduction of CO in the raw gas was decreased over 10%. Simultaneously, the gasification efficiency is also cut down 10%.

(2) Sulfide was decreased by 20% when 30% rice husk was mixed. This indicated the sulfur content of rice husk badly influenced the emission of sulfur dioxide. When the per energy output was considered, the optimum range of blending ratio at 15%-25% was found to obtain the minimum sulfide emission.

(3) When 30% rice husk was added to the coal fuel, an optimum range at about 10%-30% rice husk in the coal. This blending ratio contributed the lowest nitride emission with the highest energy output from the burning.

Therefore, 15%-25% blending ratio of rice husk in coal was obtained considering pollutant emissions and energy output. The optimum range for each pollutant emission was the not exactly the same but they were all within the range.

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