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THE EFFECT OF GAS TEMPERATURE AND VELOCITY ON COAL DRYING IN FLUIDIZED BED DRYER

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ABSTRACT

The objective of this research work is to develop fluidized bed coal dryer to overcome the disadvantages of low rank coal with high moisture such as low calorific values, costly transportation, high emissions of pollutants, and operational problem. In this paper, laboratory scale bubbling fluidized bed was used to dry high moisture, low-rank Indonesian coal to produce low moisture, high-rank coal. The effects of temperature, gas velocity and bed height to diameter ratio (L/D) on drying rate were studied to obtain information relating to optimum operating conditions. Coal characterizations (proximate analysis, ultimate analysis, Thermogravimetric Analysis (TGA), BET, Higher Heating Value (HHV), Lower Heating Value (LHV)) were performed to identify the effect of the change of moisture content. This investigation aims to study the drying process under moderated heating conditions.

As a result of the experiments the conclusion is that the thermal fluidized bed process can be successfully applied to reducing moisture in Indonesian coal. Results also indicate that about 80~90% of total moisture could be reduced, including some of the inherent moisture, yielding high heating value product. The drying rate of coal in a fluidized bed is increased by increasing the temperature and velocity of the drying gas. However gas temperature had limitations causing from the spontaneous combustion and gas velocity has to be decided considering energy efficiency.

INTRODUCTION

The high moisture content and low calorific values make the transportation of the lignite costly in the as-mined state, even though lignite resources amount to 1025 billion tons (Gt) and another 207 Gt reserves worldwide (1). And if the lignite is combusted with high moisture content, it causes higher flue gas flow rate resulting in lower plant efficiency. It could be economically treated for further processing such as combustion, gasification and liquefaction after appropriate drying processes. And a better understanding of the drying process would improve the development of the use of these low-grade coals.

Among various drying technologies, fluidized bed drying has the advantage of temperature control due to uniformity of bed temperature and high drying rate. It offers a way of drying coal in more economical end environmentally acceptable means. Drying can be done in any state of fluidization, however the optimum conditions is highly related to drying gas temperature and gas velocity (2, 3, 4).

EXPERIMENTAL
Apparatus

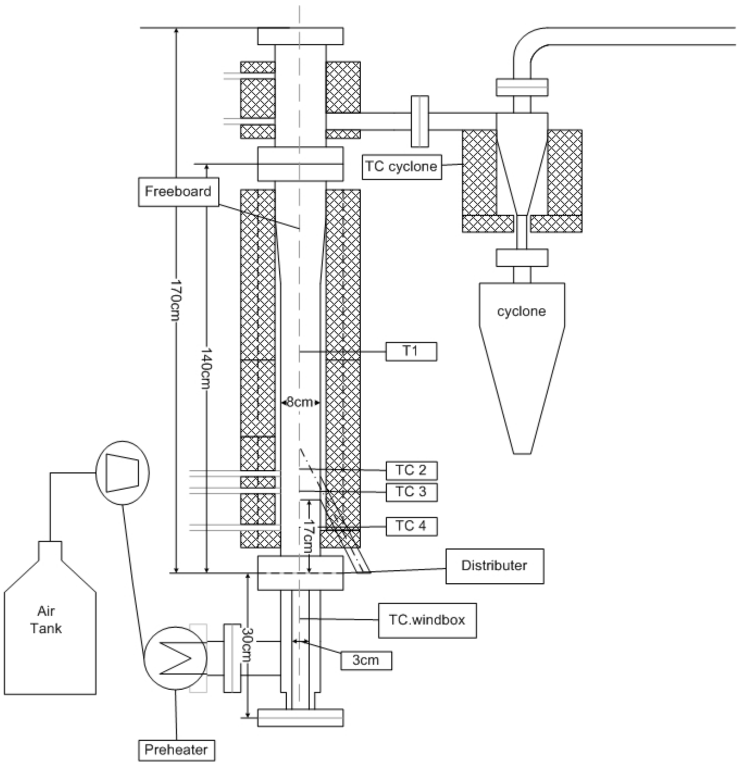

Figure 1. Schematic diagram of bubbling fluidized bed for coal drying.

Figure 1 shows the schematic diagram of the fluidized bed dryer (5). It is a batch type dryer consisting of preheater, plenums, bubbling bed, and cyclone. The height of dryer is 1.2 m and diameter is 8.0 cm.

Procedure

The drying conditions are changed for each run. For a constant drying gas velocity and L/D, the drying gas temperature was varied from 50 ℃ to 250 ℃. The drying gas velocity for constant gas temperature and L/D was varied from 0.3 m/s to 0.5 m/s. L/D (bed height to diameter ratio) was changed from 3.3 to. 4.7 for constant gas temperature and velocity. The high moisture coal was loaded onto the fluidized bed dryer after the drying gas had reached the drying temperature. During the experiment, dried coal was sampled and the moisture contents were measured using Moisture Analyzer (HR-83P, BK Technology). Thermocouples inserted into the bed were used to measure vertical distribution of bed temperature of bubbling fluidized bed dryer.

ANLAYSIS

Table 1 and 2 show the proximate analysis, ultimate analysis and heating values of Indonesian coal before and after drying, respectively. The typical thermogravimetric analysis (TGA) curve graph of the coal is shown in Figure 2 (6).

The BET surface areas before and after drying were 6.3 m^2/g and 6.5 m^2/g, respectively.

Table 1 Properties of high moisture Indonesian coal

Proximate analysis		*Ultimate analysis (wt% arb)*	
Moisture (%)	35.94	Carbon	45.75
Ash (%)	1.71	Hydrogen	7.03
Volatile matter (%)	35.30	Nitrogen	0.68
Fixed carbon (%)	27.05	Sulphur	0.03
Higher heating value (kcal/kg)	5900	Oxygen	44.80
Lower heating value (kcal/kg)	4990		

Table 2 Properties of dried Indonesian coal

Proximate analysis		*Ultimate analysis (wt% arb)*	
Moisture (%)	5.22	Carbon	66.65
Ash (%)	2.31	Hydrogen	5.07
Volatile matter (%)	47.16	Nitrogen	0.89
Fixed carbon (%)	45.31	Sulphur	0.02
Higher heating value (kcal/kg)	6120	Oxygen	25.06
Lower heating value (kcal/kg)	5800		

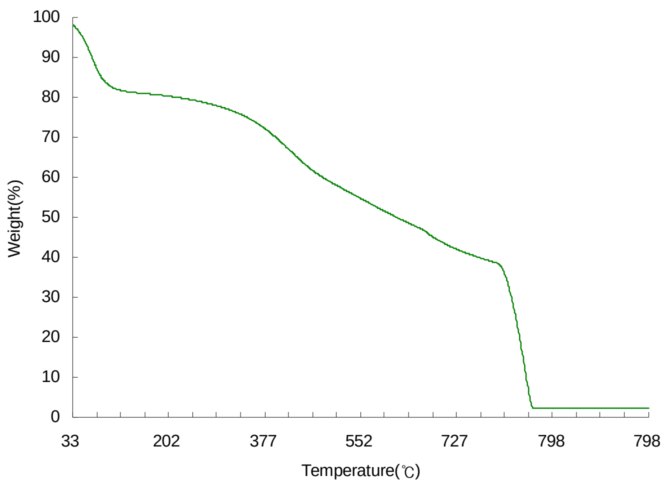

Figure 2. Thermogravimetric curve graph of Indonesian coal

RESULTS AND DISCUSSION

Figure 3 shows the moisture contents as a function of time for various gas temperatures at constant gas velocity and length to diameter ratio (L/D). The drying rate curves obtained from Figure 3 are shown in Figure 4. The slopes of the curves in Figure 3 designate rate of drying. It is seen that the drying rate increases as the gas temperature increases. In Figure 5, temperature distribution in fluidized bed dryer at 150℃ of gas temperature are shown. The results indicate that most of heats from the drying gas are utilized for the removal of moisture in coal showing that the fluidized bed drying is useful method in terms of energy efficiency.

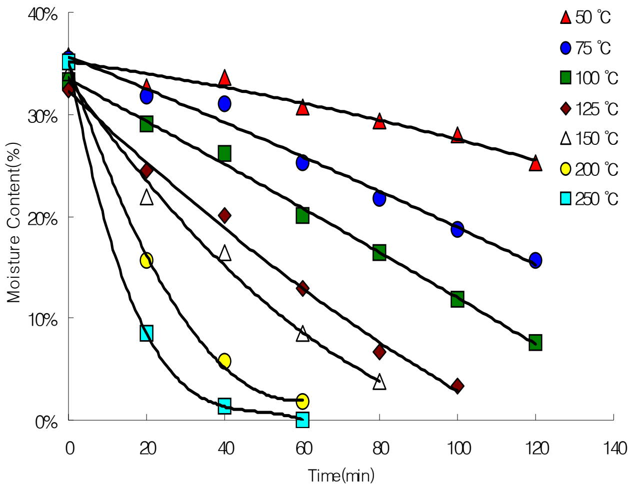

Figure 3. The effect of gas temperature on moisture content of coal (U=0.3 m/s, L/D=4.0)

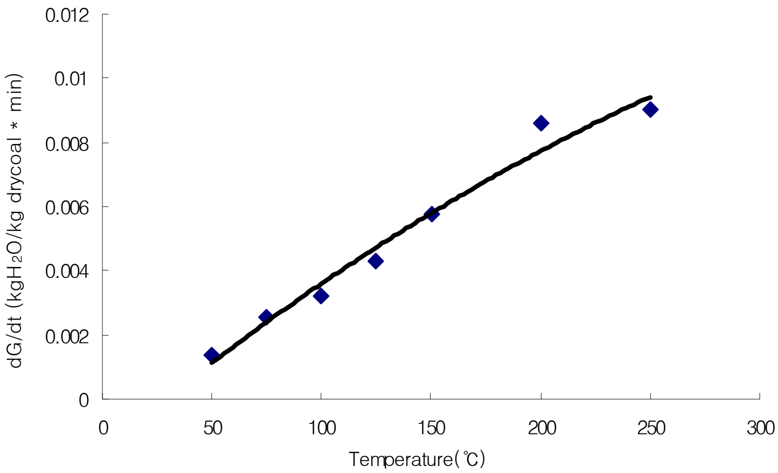

Figure 4. Drying rate for coal vs. gas temperature (U=0.3 m/s, L/D=4.0)

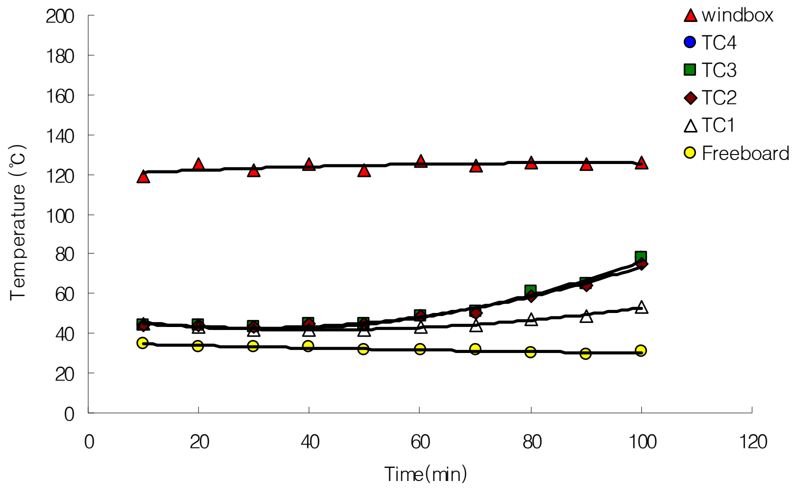

Figure 5. Temperature distribution in fluidized bed dryer at 150℃ of gas temperature (U=0.3 m/s, L/D=4.0)

Figure 6 shows the moisture contents for various gas velocities at constant gas temperature and length to diameter ratio (L/D). The drying rate curves obtained from Figure 6 are shown in Figure 7. It is seen that the drying rate increases as the gas velocity increases. It is obvious that the heats to the coal particles for the drying of coal increases as the gas velocity increases and, in turn, the drying rate increases. However, if the gas velocity increases over limited value, the energy efficiency will decrease since wasted heats to the atmosphere increases. Therefore, the optimum gas velocity needs to be decided for the optimum drying condition.

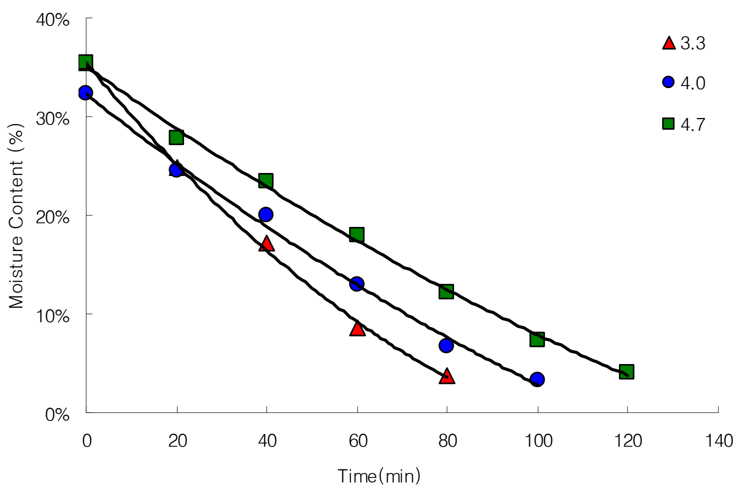

Figure 6. The effect of gas velocity on moisture content of coal (T_{gas} = 150℃, L/D=4.0)

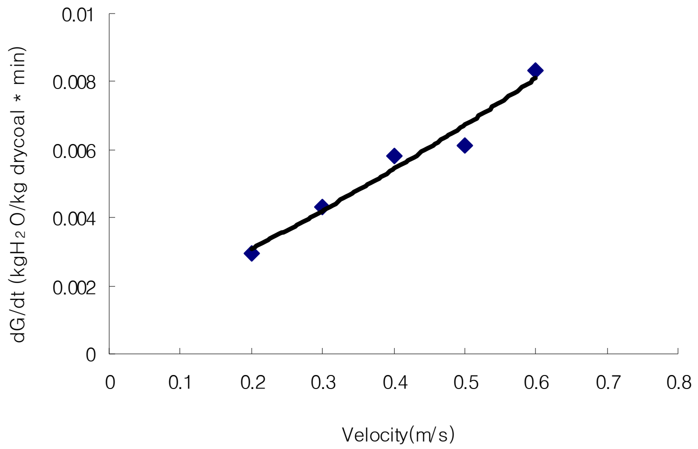

Figure 7. Drying rate for coal vs. gas velocity (T_{gas} = 150℃, L/D=4.0)

Figure 8 shows the moisture contents for various L/D at constant gas temperature and gas velocity. The drying rate curves obtained from Figure 8 are shown in Figure 9. It is found that the drying rate decreases as L/D increases. Since the amount of coals dried increases as L/D increases, the drying efficiency of fluidized bed could be increased even though the drying rate decreases. Since there is a limitation in bed height for the fluidized bed dryer, optimum L/D value also needs to be decided for the efficient coal drying.

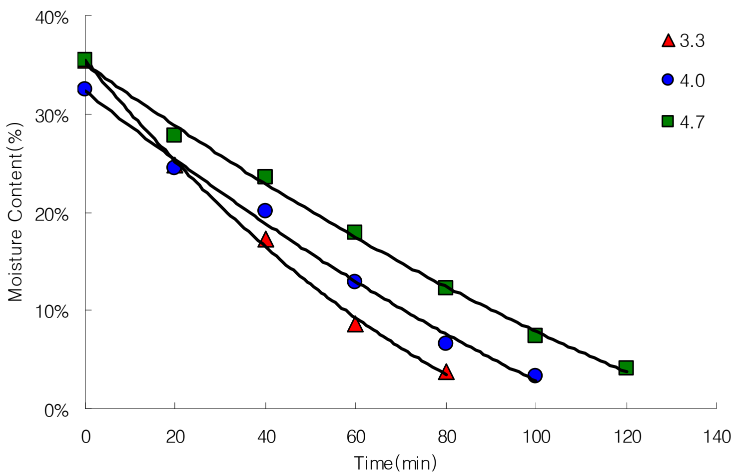

Figure 8. The effect of L/D on moisture content of coal (T_{gas} = 125℃, u = 0.3 m/s)

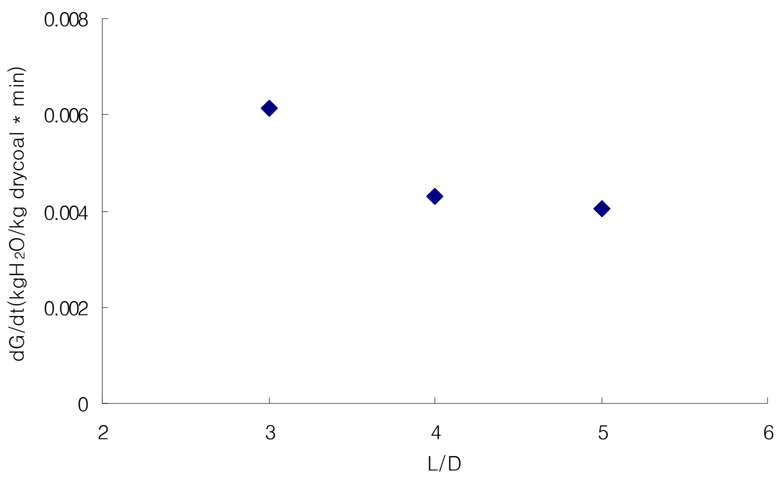

Figure 9. Drying rate for coal vs. L/D (T_{gas} = 125℃, u = 0.3 m/s)

CONCLUSIONS

A laboratory-scale bubbling fluidized bed drying experiments of Indonesian coal were performed to identify the optimal operation conditions. It has confirmed that the drying of moisture from coal particles in a fluidized bed was increased by increasing the drying gas temperature and velocity.

Drying of coal has a significant positive effect on performance of existing and newly constructed power plants. Furthermore, the improvement of heating values of dried coal will have advantages on plant capital cost.

Fluidized bed drying is an advanced technology for high moisture, low rank coal such as lignites and sub-bituminous coals. In addition, fluidized bed drying seems to be a practical method for the removal of moisture content of high moisture, low rank coal in points of energy efficiency and economical view.

ACKNOWLEDGEMENT

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