Application of Rotary Drum Dryer at Ombilin Coal Fired Power Plant

Mujammil Asdhiyoga Rahmanta and Muhammad Iqbal Felani

***Abstract*—PLN as State-Owned Company of Indonesia has 10.000 MW fast track projects of Coal Fired Power Plant (CFPP) which is designed for using Medium Rank Coal (MRC). PLN has not got MRC due to government policy of trading of coal. While Indonesia has a lot of Low Rank Coal (LRC) reserves nowadays. Ombilin CFPP 2X100 MW has used rotary drum dryer to increase High Heating Value (HHV) of LRC by reducing total moisture of water in coal. Rotary drum dryer uses flue gas from its furnace as heat source. Rotating test in various speeds is used to know the characteristic product (fixed carbon, total moisture, and HHV) of rotary drum dryer at Ombilin CFPP. The temperature of flue gas (heat source), the type of coal input, and the other operation parameters are maintained approximately constant when speed is adjusted.**

***Index Terms*—High heating value, rotary drum dryer, rotating speed, total moisture.**

I. Introduction

Proximate analysis of coal is divided coal into 4 parts such as moisture content, volatile matter, fixed carbon, and ash content. Coal deposits which can generate heat energy through combustion reaction are volatile matter and fixed carbon [1]. Removing moisture content of coal by drying can increase HHV. Drying occurs by effecting vaporization of the liquid by supplying heat to the wet feedstock. As noted earlier, heat may be supplied by convection (direct dryers), by conduction (contact or indirect dryers), radiation or volumetrically by placing the wet material in a microwave or radio frequency electromagnetic field. Over 85 percent of industrial dryers are of the convective type with hot air or direct combustion gases as the drying medium. Over 99 percent of the applications involve removal of water. All modes except the dielectric (microwave and radio frequency) supply heat at the boundaries of the drying object so that the heat must diffuse into the solid primarily by conduction. The liquid must travel to the boundary of the material before it is transported away by the carrier gas (or by application of vacuum for non-convective dryers) [2].

An experimental and numerical study has been carried out by researchers on coal drying and rotary dryer designs. Yilmazoglu *et al.* [3] compared the performance of a rotary dryer by using two kinds of heat source. He used natural gas burner and parabolic solar system as heat sources. Margono *et al.* [4] analyzed the effects of feed rate and residence time in rotary dryer using steady-state and unsteady-state plug flow models. Partial differential equations describing heat and mass transfer in the rotary dryer were derived from shell balance. The results show that evaporated feed moisture content in plug flow back mixing model was lower than in plug flow model. Drying system is used in processes to obtain the required moisture content of the feed. Fagernas *et al.* [5] compared several types of dryers in a biomass drying process. They also investigated the environmental effects of dryers and offered different dryer types with respect to the feed characteristic and feed mass flow rate. Kakaras *et al.* [6] performed a simulation to investigate the effects of brown coal drying on a thermal power plant. Different types of dryers were compared and the thermal efficiency of the power plant was improved 5% by drying.

For each and every product, there is a representative curve that describes the drying characteristics for that product at specific temperature, velocity and pressure conditions. Fig. 1 shows a typical drying curve. The variations in that curve will occur principally in relative rate to carrier velocity and temperature.

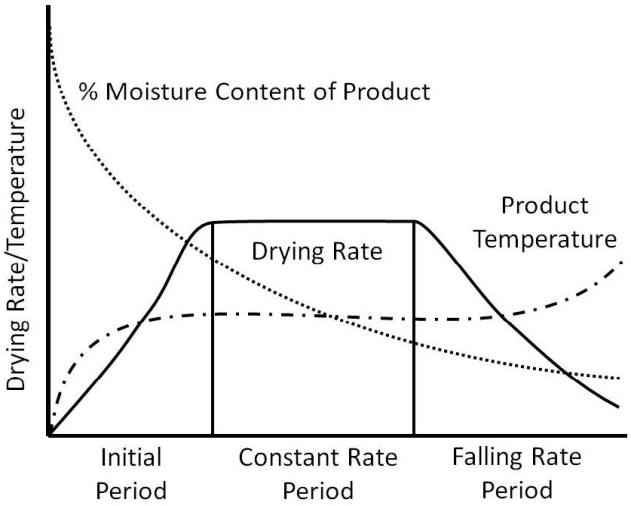

Fig. 1. Drying curve [7].

The first phase (initial period) is where sensible heat is transferred to the product and the contained moisture. This is the heating up of the product from the inlet condition to the process condition, which enables the subsequent processes to take place. The rate of evaporation increases dramatically during this period with mostly free moisture being removed. In some instances, pre-processing can reduce or eliminate this phase. The second phase (constant rate period) is when the free moisture persists on the surfaces and the rate of evaporation alters very little as the moisture content reduces. During this period, drying rates are high and higher inlet air temperatures than in subsequent drying stages can be used without detrimental effect to the product. There is a gradual

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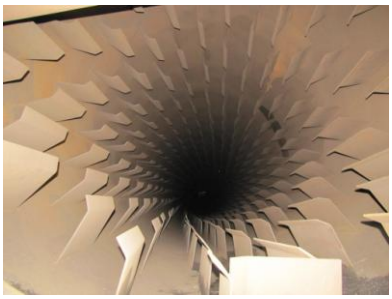
and relatively small increase in the product temperature during this period. The third phase (falling rate period) is the phase during which migration of moisture from the inner interstices of each particle to the outer surface becomes the limiting factor that reduces the drying rate.

There are several types of coal dryer such as rotary drum dryer, mechanical spouted dryer, screw conveyor dryer, and fluidized bed dryer [7]-[9]. Rotary drum dryer can use flue gas or steam as heat source. Rotary dryer rotates coal to make heat distribution inside the drum. Screw conveyor dryer use screw mechanism to move the coal and distribute heat. Steam is used as heat source to dry the coal. Spouted dryer used horizontal screw to rotate the coal and distribute heat. Flue gas generated from furnace is blown from the bottom of container. Heat source has different direction or counter flow with the coal. Fluidized bed dryer uses hot gas that flowed into the bed that contains granules/particles of the object to be dried. With a certain velocity, hot gas will cause the particles mixed and then at a certain moment that have been dried particles will be carried out of the bed.

(a) Side view



(b) Inner rotary drum

(c) furnace of dryer

Fig. 2. Rotary drum dryer at Ombilin CFPP.

Fig. 2 shows rotary drum dryer at Ombilin CFPP 2×100 MW. It is located at the plant site. It has capacity 30 ton/h and heat source from flue gas which produced by coal furnace. It has 30 m of length and 3 m of diameter. The size input of coal is 3-4 cm. The flue gas has temperature approximately 300 ^{0}C and direct contact with coal in order for drying. This rotary drum dryer has supplied 20% of fuel in Ombilin CFPP.

II. Methodology and Experiment

A. Methodology

Experiment is conducted by testing of operational rotary drum dryer in various speed of rotation (14, 15, and 16 rpm). The temperature of flue gas is maintained in range at 300 ^{0}C $\pm$ 30 ^{0}C. Coal which tested is came from same mine. The relationship between rotating speed with decreasing moisture, increasing fixed carbon, and HHV of rotary drum dryer is known by this experiment.

B. Experiment of Operational Rotary Drum Dryer

The speed is adjusted into 14, 15, and 16 rpm every 1 hour. Speed correlate with the resident time of heating coal, it means that lower speed will make heating time to be longer and higher water content in coal will be evaporated. But, low speed will reduce the capacity. High speed will increase capacity but reducing water content in coal will be lower. The experiment is held at 18th -19th July 2013.

III. Result and Analysis

A. Coal Properties

TABLE I: Proximate Analysis of Coal

Rotating speed (rpm)	Coal	Proximate Analysis			
		Total moisture (%)	Ash (%)	Volatile matter (%)	Fixed carbon (%)
14	Input	33.08	5.95	35.92	25.05
	Output	23.08	6.24	40.01	30.67
15	Input	35.81	4.93	33.88	25.38
	Output	27.22	4.9	38.19	29.68
16	Input	32.67	5.85	35.93	25.55
	Output	25.13	5.64	39.50	29.73

Table I shows that reducing water content or total moisture by drying will increase fixed carbon content. Volatile matter will increase but ash content remains constant after drying.

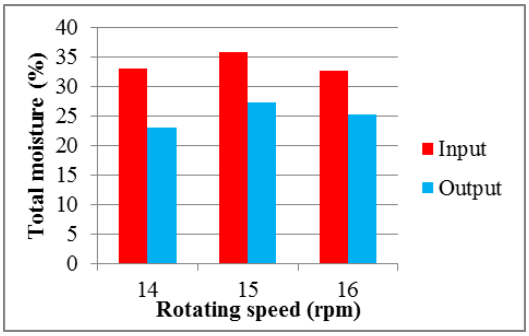
TABLE II: Property Difference and Caloric Value of Coal

Rotating speed (rpm)	Coal	Proximate Analysis		HHV (kCal/kg)	Increasing HHV (%)
		Reducing total moisture (%)	Increasing fixed carbon (%)		
14	Input	30.23	22.44	4,022.32	16.81
	Output			4,698.52	
15	Input	23.99	16.94	4,005.84	12.54
	Output			4,508.32	
16	Input	23.08	16.36	4,146.97	10.80
	Output			4,594.76	

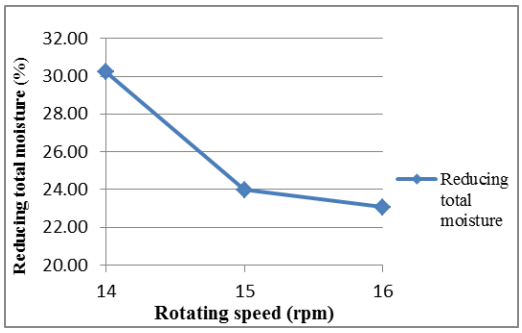
Table II shows the percentages of reducing of total moisture, increasing fixed carbon and HHV of coal

properties.

B. Total Moisture



(a) Rotating speed vs total moisture

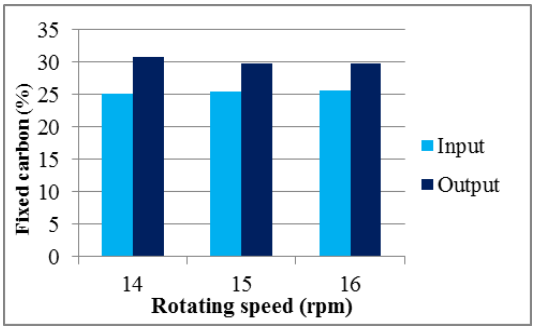


(b) Rotating speed vs reducing total moisture

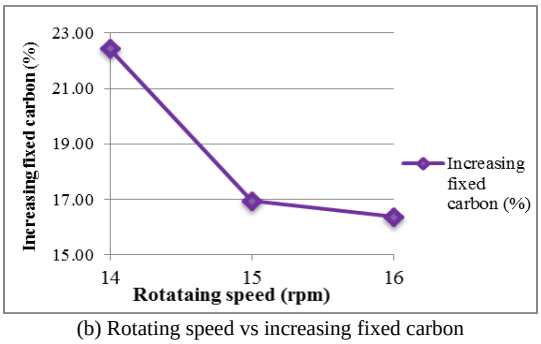
Fig. 3. Graph between rotating speed and total moisture.

The Fig. 3 shows that rotating speed at 14 rpm reduces 30.23% of total moisture from 33.08% into 23.08%, 15 rpm reduces 23.99% of total moisture from 35.81% into 27.22%, and 16 rpm reduces 23.08% of total moisture from 32.67% into 25.31%. Lower rotating speed has made higher water content to be evaporated and reducing higher total moisture in coal.

C. Fixed Carbon



(a) Rotating speed vs fixed carbon

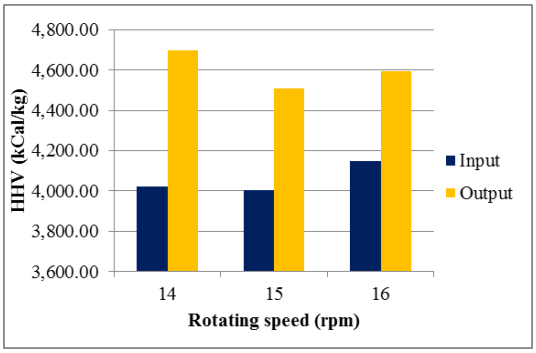


(b) Rotating speed vs increasing fixed carbon

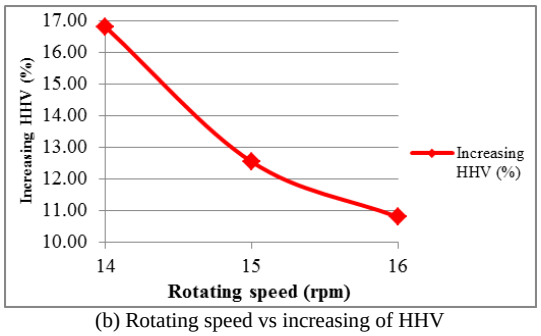
Fig. 4. Graph between rotating speed and fixed carbon.

Fig. 4 indicates that rotating speed at 14 rpm increases 22.44% of fixed carbon from 25.05% into 30.67%, 15 rpm increases 16.94% of fixed carbon from 25.38% into 29.68%, and 16 rpm increases 16.36% of fixed carbon from 25.55% into 29.73%. Lower rotating speed has made higher of increasing fixed carbon. Fig. 4 (b) and Fig. 5 (b) have similar trend, they show that higher reducing of total moisture will have made higher increasing of fixed carbon and lower reducing of total moisture will have made lower increasing of fixed carbon.

D. High Heating Value



(a) Rotating speed vs HHV



(b) Rotating speed vs increasing of HHV

Fig. 5. Graph between rotating speed and high heating value.

Fig. 5 shows that rotating speed at 14 rpm increases HHV about 16.81% from 4,022 kCal/kg into 4,698 kCal/kg, 15 rpm increases HHV about 12.54% from 4,005 kCal/kg into 4,508 kCal/g, and 16 rpm increases HHV about 10.80% from 4,146 kCal/kg into 4,594 kCal/kg. Lower rotating speed has made higher of increasing HHV of coal.

IV. Conclusion

Rotary drum dryer at Ombilin CFPP has characteristic which depended on the rotating speed of dryer. Rotating speed at 14 rpm reduces 30.23% of total moisture and increases 22.44% of fixed carbon. Rotating speed at 15 rpm reduces 23.99% of total moisture and increases 16.94% of fixed carbon. Rotating speed at 16 rpm reduces 23.08% of total moisture and increases 16.36% of fixed carbon.

Highest increasing of HHV about 16.81% has been happened when rotating speed is 14 rpm. Lowest increasing of HHV about 10.80% has been happened when rotating speed is 16 rpm.

Adjusting lower rotating speed of rotary drum dryer makes higher reducing of total moisture, it will have made higher

increasing of fixed carbon and HHV. Adjusting higher speed of rotary drum dryer makes lower reducing of total moisture, it will have made lower increasing of fixed carbon and HHV.

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