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Briquette technology of low grade Indonesian coal

The distribution of low rank coal in many geographies accounts for almost 50% of the coal deposits of the world. Presence of high moisture and high propensity for spontaneous combustion limits its use in industries. An attempt towards reducing the moisture and enhancing calorific value would make the low rank coal more usable for different industries. For this study Indonesian coal has been considered as there are large resources of lignite/low rank coal specifically in Sumatra. Low rank coal (LRC) is also known as lignite or brown coal which has moisture content up to 45%. Their applications are limited due to spontaneous heating property, high volatile matter (VM). LRC is difficult to handle and involves high transportation cost also. If coal is only dried, it turns brittle and breaks down into dust while handling. After extensive research on Indonesian coal at laboratory and pilot scale, briquetting technology appears to overcome these inherent difficulties of LRC and is ready for experimental production. With briquette technology, coal is dried into tailor made briquettes of adequate strength. There are various advantages of coal briquettes like lower moisture content, higher heating value, improved plant efficiency, enhance safety, low transportation cost, reduce fire hazard, reduce space requirement and reduce green house gas emissions etc. Briquette technology can help standardizing Hardgrove Grindability Index (HGI) of coal and can be maintained at a value as suitable to the end user. This paper deals with briquetting technology which can produce 2000 TPD of desired quality briquetted coal out of low rank coal on a commercial scale.

Keywords: *Low rank coal, Briquette technology, volatile matter, Hardgrove grindability index.*

1.0 Introduction to LRC

Indonesia became the world's largest exporter of thermal coal and is a major supplier to the Asian coal market. Indonesia has had a long history of coal production, mainly in Sumatra and Kalimantan, but the real surge took place in the last two decades. Most of the coal in Indonesia were formed in Paleogene and Neogene having low to moderate rank and also have low ash and low sulfur (generally < 10 &< 1 wt.%, respectively). Active tectonic and igneous activity has resulted in significant rank increase in some coal basins. The sub-bituminous to bituminous tertiary coals of SE-Asia differ fundamentally from the geographically close Permotriassic Gondwana coals (Australia, India or S. Africa) or from the carboniferous coals of Laurasia.

The coal measures in the middle Palembang formation developed between the Asian landmass and the rising Barisan range after the closing of channels through the Barisan volcanic arc. They extend from central Sumatra over more than 700 km to south Sumatra, and are exploited since decades at Bukit Assam, where the three main coal seams have an average aggregate thickness of about 30 to 40 m. Several minor seams, lenticular shales, sandstones, are interbedded. The coal rank depends mainly on the proximity to igneous intrusives. In general, the usually claritic coals with distinct resins are lignite to sub-bituminous coal, although the coal rank improves even to anthracite in thermal alteration haloes[1]. Hence we will be focusing on these types of inferior coal for the present paper.

2.0 Processes for dewatering/drying of low rank coal

The amount of presence of moisture in coal impacts the heating value immensely and hencethe marketability. The moisture present on the surface or in the secondary spaces like fractures, small pores could be removed to some extent using a suitable drying method. Dewatering or drying of these low rank coal points to the initial step towards upgrading the heating value of coal. Low rank coal (LRC) when heated above the boiling point of water to vaporize fluid, it does not alter thermally or oxidize coal. However, various drying and subsequent methods have been designed to minimize energy consumption and make the system efficient and economically viable for producing an acceptable coal fuel type for thermal power plants and other allied industries. High moisture content makes drying of LRC an essential component in any upgrading or utilization process. For

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example, drying of LRC can result in major savings in transportation costs. According to Lucarelli [4], a coal producer can save \$0.19 = GJ of energy on storage, handling, and transportation costs if LRC is dried from 35% to just 25% moisture content, and the savings on logistics costs could be as high as \$7 million per year for a 600-MW plant.

LRC presents a fire hazard if necessary measures are not taken to prevent spontaneous combustion of the material. One way of preventing unwanted ignition of coal during drying is by utilizing a drying medium that has low oxygen content. Superheated steam (SHS) is one such medium. The use of superheated steam, however, involves enormous capital expenditure due to the cost associated with the construction and operation of the steam system. Another way of preventing the spontaneous combustion of coal is by employing indirect heat treatment using indirect dryers, thereby minimizing the direct contact of LRC with an oxygen-rich drying medium. Dried LRC is also susceptible to self-ignition when exposed to excessive moisture; this tendency increases as the particle size becomes smaller. Hence, there is a need to properly store dried LRC for the sake of safety and to minimize re-adsorption of moisture so that the lower moisture in the dried coal can be maintained. Various methods to minimize moisture re-adsorption exist and have been discussed by Jangam et al[3]. However, it remains to be seen whether such methods are cost-effective when a massive amount of coal is involved. Loss of volatile organic compounds (VOCs) as a result of drying LRC at high temperatures is another issue that must be addressed. The loss of useful volatile matter from LRC reduces its calorific value and increases the risk of fire from the combustion of VOCs. Drying at lower temperature or by using a slight vacuum environment can minimize the loss of VOCs. However, these approaches result in a lower rate of drying.

The diverse nature of LRC found worldwide requires that the LRC dryer be fine-tuned according to the bulk properties of the specific LRC to ensure optimal dryer performance. The moisture content of LRC as well as its other properties varies over a wide range depending on its origin; hence, the choice of dryer for LRC application is not universal. The typical characteristics of Indonesian LRC has CV - 21 to 23 MJ/Kg, moisture of 15-22%, fixed carbon of 37 to 40%, VM of 37 to 41%, sulphur of 0.5-4% (daf) and Ash of 2-8% (db).

Drying methods and processes can be classified in many ways. Dryers can be either batch or continuous type or can be grouped according to how heat is transferred to the wet material. Here, dryers are grouped according to their physical design and the principle of operation. Dryer selection is also affected by geographical location, value of the product, safety considerations, and the scale of operation. In addition, downstream processing and utilization of coal can have an important bearing on the selection of the dryer type. The various subsequent processes starting from drying are discussed below.

a. Rotary dryers
b. Drying based on showering of particles
c. Drying with aeration
d. Drying with unconventional flow of solids
e. Rotary tube drying
f. Combination of direct and indirect drying
g. Fluidized bed dryers (FBD)
    i. Multistage FBD
    ii. Multilevel FBD
    iii. Pulsed FBD
    iv. FBD with immersed heater
    v. Fluid bed dryers
h. Microwave dryers (MW)
    i. Stand-alone MW dryers
    ii. MW-assisted dryers
i. Screw conveyor dryers (SCD)
    i. Multistage SCD
    ii. Dewatering using tapered-shaft screw conveyor
j. Drying with super heated steam
k. Integrated drying
l. Incremental moisture reduction

3.0 Solvent displacement

In addition to oil, drying of coal in other hydrocarbons has also been demonstrated with success. Grounded coal immersed in hot molten paraffin was also shown to be another effective dehydration method. Dean showed that coal treated

TABLE 1: DIFFERENT TYPES OF MOISTURE IN COAL AND TYPICAL METHODS FOR REMOVAL

Type of water	Effective position	Common name	Removal method
Interior adsorption water	Micro-pores and micro-capillaries within each coal particle	Inherent moisture	Thermal or chemical
Surface adsorption water	Particle surface	Inherent moisture	Thermal or chemical
Capillary water	Capillaries in coal particles	Inherent moisture	Thermal or chemical
Inter-particle water	Small crevices found between two or more particles	Surface moisture	Mechanical or thermal
Adhesive water	Film around the surface of individual or agglomerated particles	Surface moisture	Thermal or chemical

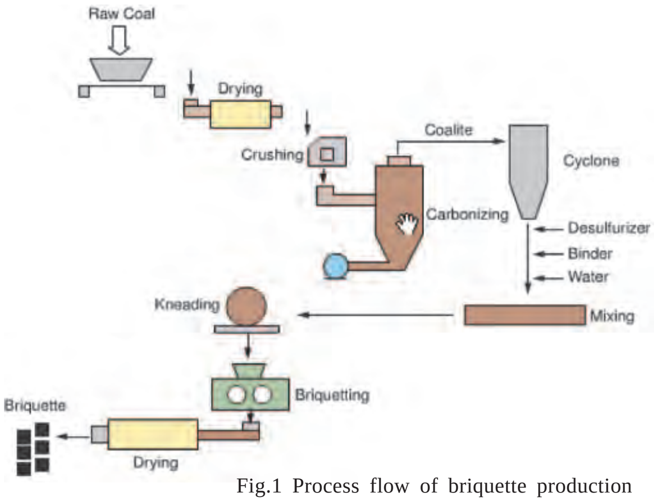

Fig.1 Process flow of briquette production

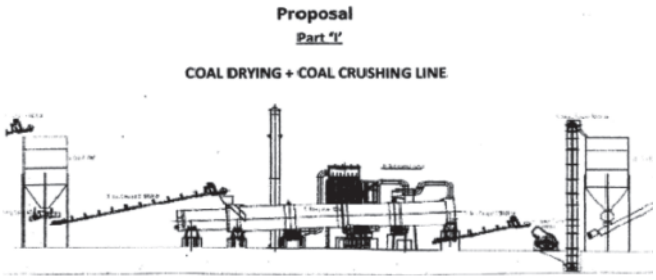

Fig.5 Proposal for coal drying and coal crushing line 50 TPH

using such a process displayed a dramatic increase in calorific value (originally 22,300 kJ = kg, upgraded up to 34,900 kJ = kg), low final moisture content (around 3%), and inhibited rehydration due to paraffin displacement of water in coal cavities.

Fig.2 Laboratory equipment (a) Coal crusher (b) Vessel (c) Rotary drier

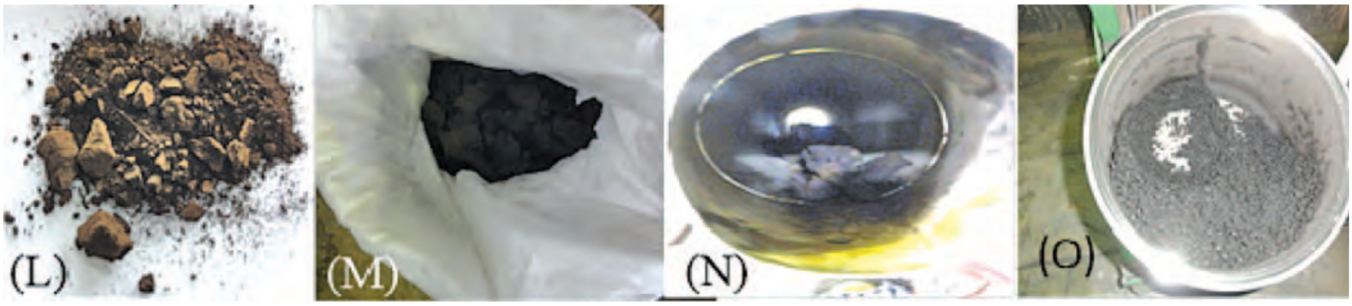

Fig.3 Trial product results with rotary drier L, M , N and O

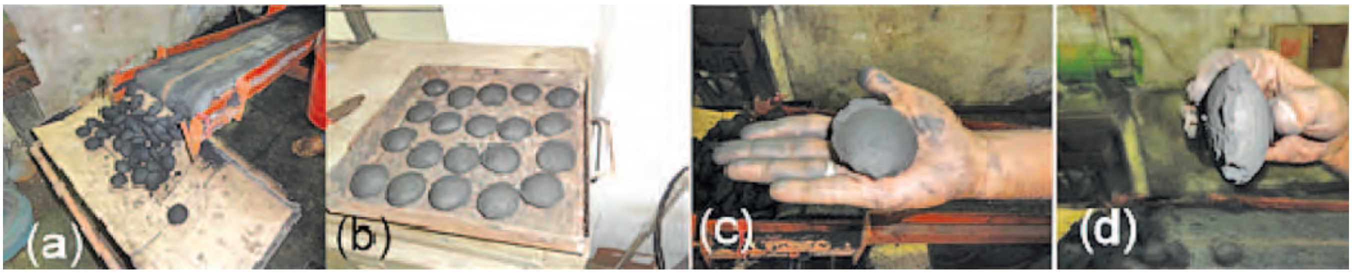

Fig.4 Coal briquettes (a) raw (b) drying (c) top view (d) side view

Superheated steam drying can result in better energy consumption values but at higher overall costs. Because the process requires a considerable amount of capital expenses and also uses electricity for compression, the overall economic potential yet to be determined. The concept of displacing water with low-latent-heat solvents is not new. It has been proposed and tested for drying of plastic components, textiles, etc., but has not yet been successfully commercialized. The recovery of solvent by cost-effective means remains the main concern. Considerable pilot-scale tests and techno-economic studies are needed before this process can be considered for commercial application.

4.0 Briquetting

Briquetting of coal stems from the need to reclaim stockpiles of coal fines left over from screening, grinding, drying, and other processes. Coal particles that are too small have negligible economic value because they cannot be shipped without re-agglomerating them to a larger size. For example, some of the processes for synthetic fuels cannot use coal particles smaller than 14 mm. In addition to the convenience of size, briquetting of coal can minimize moisture re-adsorption and increase calorific value as well as the density of the agglomerate. Fig.1 shows the process flow diagram of briquette production. Fig.2 shows laboratory equipment used for trials during briquetting of Indonesian coal.

Typical in a briquetting process, lignite containing 48-70% water is crushed to particles of 0.01-3mm which are then dried to about 12-15% moisture content. The dried coal particles are then subjected to an extrusion press at low to high pressures to form hard compacts similar to a calorific value of high-rank coals. In some cases, additives are blended to agglomerate and improve the strength of the product. The actual process and operating conditions of a briquetting process may vary depending on the properties of the raw material, the desired characteristics of the product, and the equipment used.

The different processes mostly accepted for briquetting of low rank coal are like densified brown coal (DBC) process patented by Johns et.al. and the Coldry processes patented by Willson[5]. The key difference between the DBC and Coldry processes is the use of drying equipment in the latter. Results with rotary drier are shown in Fig.3.

Use of various binders such as tar, pitch, petroleum residues, humic acid, polyvinyl chloride (PVC), atactic polypropylene, plastic waster, wood pulp waster liquor, molasses, biomass, starch, lime, clay, ceramic etc have been reported. The use of a binding agent prevents the compressed material from returning to its original form. The softening of binding agents at elevated temperatures and subsequent hardening upon cooling result in hard and compact agglomerates that do not break easily. However, the strength of the briquette is largely dependent on the properties of the raw materials, the amount of binder added, and the process conditions. Coal briquettes, as final product at laboratory level during different stages, are shown in Fig.4. Proposed coal crushing and crushing line for pilot production is shown in Fig.5.

5.0 Conclusion

Finally, conventional coal drying techniques produce substantial amounts of coal fines due to weakened coal structure caused by removal of water. The presence of excessive coal fines poses safety risks, pollutes the environment, and demands substantial resources for its suppression. It is always important to calculate the bottom line and the cost-effectiveness of any drying system selected. Because drying is a means of upgrading LRC so that it can be sold at a higher price, it is important to calculate a priori the economic benefit accrued due to reduced transportation costs and increased market value as a result of improved calorific value. Sulfur content and ash content of LRC have important effects on the market value as well.

The major advantages of briquetting of low rank coal are like reduced moisture content of coal reduces the transportation cost, enhances CV, reduced fire hazards and sulphur, minimizes the space constraints for storage and helps maintaining uniform feed rate during crushing operation.

In brief it can be said that briquetting is a method by which low rank coal can be effectively used with low pollution levels and with more energy savings.

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