Sci., Tech. and Dev., 32 (1): 40-43, 2013

SOME STUDIES ON COAL BRIQUETTING

ISMAT ALI*

Fuel Research Centre, PCSIR, Karachi, Pakistan.

Abstract

Briquetting of coal is carried out for better utilisation of coal in general and lignites in particular. Studies carried out on various compositions of coal briquetting material (one composition with Lakhra lignite, clay, water, limestone and another with quicklime) are presented. Studies were mainly aimed at improvement in ignition/combustion, environmental impact and energy potential of coal briquettes.

Keywords: Briquetting of coal, Energy, Environment, Lakhra lignites, Combustion.

Introduction

Coals are classified as anthracite, bituminuous and lignite depending on the carbon content and energy potential after Perry, 1963 (Table 1). Anthracite coal is superior and used for space heating as its combustion is environmentally safer. Bituminuous coal is used particularly for coking purposes in steel mills. Coke in steel mills is used as reducing agent (enrichment of iron) as it reacts with the oxygen of the iron ore (normally, iron ore contains oxides of iron, i.e., FeO, Fe_2O_3, Fe_3O_4 and FeS, etc.). Lignites are low grade coals, normally, used for power generation. About 187 billion tonnes of coal, mostly lignite, are available in the country. According to an economic survey conducted by the Government of Pakistan, about three million tonnes of coal have been annually mined for the last thirty years and consumed in brick kilns for baking bricks (Govt. of Pakistan, 1992-93). Less than one percent of coal is being used for power generation as its combustion is not safe from environmental point of view. Pakistani lignites are rich in mineral matter (due to high sulphur and ash contents–inorganic compounds/ complexes) (Table 2). The washing of such a coal is neither technically favourable nor economically feasible. Hydrocylonical washing of these coals is not technically possible as these are heavier than water because these are rich in mineral matter; hence do not float on water. Chemical cleaning is not possible as sulphur in these coals is in various forms (organic, inorganic, pyritic etc.) which is difficult to remove as it is the integral part of the coal composition. Therefore, lignites are used as such without washing after pre-treatment for utilisation in various sectors. These coals are used in power plants using atmospheric fluidised bed combustion (AFBC) technique in which a mixture of lignites with limestone is fluidised in the combustion zone, composed of silica sand, at about 800°C (minimising agglomeration, i.e. melting of mineral matter). Coal catches fire and reacts with limestone to form calcium sulphate ($CaSO_4$).

One of the most easiest/convenient methods to utilise Pakistani lignites is coal briquetting (Ali, 1994). Briquetting of coal from Sharigh and Degari coal fields of Balochistan has been carried out between 1942 to 1992 at Quetta on a 100 tonnes per-day British briquetting press-operated

Table 1. Classification of Coals

Constituents	Peat	Lignite	Bituminuous	Anthracite
Carbon	**60.0**	**67.0**	**88.4**	**94.1**
Hydrogen	**5.9**	**5.2**	**4.6**	**3.4**
Oxygen	**34.1**	**27.8**	**7.0**	**2.5**
	100.0	**100.0**	**100.0**	**100.0**
Heating value	**27.8**	**25.27**	**26.3**	**34.6**

***Author for correspondence E-mail:pakassp@gmail.com**

on steam produced from the combustion of coal. Ten thousand tonnes of coal briquettes of 100gm mass were annually produced and used for warming sheds of soldiers stationed there in winter (Ali, 1996). Studies, carried out in 2003, on the material of coal briquetting for trapping sulphur of lakhra coal, environmental impacts and ignition/combustion, are presented here.

Material and Method

A mixture of Lakhra lignite, limestone, quicklime, clay and water were used in various compositions for briquetting for the production of briquettes of average mass of 7.0gm each. The compositions are presented as follows:

Composition 1:	Composition 2:
Lakhra lignite 60 % (coal 48 % + 12 % as inherent moisture)	**Lakhra lignite 60 % (coal 48 % + 12 % as inherent moisture)**
Limestone($CaCO_3$) 20 %	**Quicklime (CaO) Pre-prepared 20 %**
Clay 10 %	**Clay 10 %**
Water 10 %	**Water 10 %**
100 %	**100 %**

Limestone, clay and water are used for fixing sulphur as calcium sulphate and as binding agents for composition 1.

Quicklime, clay and water are used for fixing sulphur as calcium sulphate and as binding agents for composition 2.

Ultimate analysis of Lakhra lignite had been carried out on LECO, CHN-600, proximate analysis of coal on LECO, Mac 400 and sulphur on LECO SC-132. The results are presented in Tables 2 and 3. The analysis of $CaCO_3$ is presented in Table 4. 5.0gm of powdered limestone was taken in a petri dish. Moisture of powdered limestone was determined by heating at 110^0C for two hours. No loss of mass was observed. Limestone contained no moisture. 2.15gm loss of limestone was observed on heating it at 800^0C which was due to release of CO_2, as shown below:

- Powdered Limestone 5.00 gm.
- Residue after heating at 800^0 C 2.85 gm.
- Mass loss due release of CO_2. 2.15 gm.
- Percent of residue.(2.85/5.0)100 = 56.92
- Purity of limestone.(56/56.92)100= 98.38

Table 2. Ultimate analysis of Lakhra Lignite. Oxygen is calculated by subtracting the sum of carbon, hydrogen, nitrogen, sulphur and ash from 100.

Elements	Percent
Carbon	34.21
Hyrdogen	5.34
Nitrogen	0.61
Sulphur	5.60
Ash	25.60
Oxygen	28.64

Table 3. Proximate analysis of Lakhra Lignite. Fixed carbon is determined by subtracting the sum of the percentages of moisture, volatile matter and ash from 100.

Constituents	Percent
Moisture	12.00
Volatile matter	28.23
Ash	25.60
Fixed carbon	34.17

Table 4. Analysis of Limestone

Constituents	Percent
CaO	56.92
CO_2	43.08

Twenty briquettes (ten with limestone and ten with quicklime) were marked and weighed. Coal briquettes were placed in a technically designed stove with two meter long chimney inverted on the stove, for ignition/combustion of 2 kg of coal briquettes. After complete combustion of coal briquettes, next day, ash of twenty marked briquettes (in the shape of burnt briquettes) was picked up and weighed on an electronic Sartorius balance. The results are presented in Tables 5 and 6. The ten briquettes of each composition were pulverised and mixed homogeneously for the determination of sulphur for comparison of sulphur trap.

Table 5. Ash percent of briquettes with limestone

Mass of Briquettes	Ash	Percent of Ash sulphur	Sulphur
7.02	2.18	31.05	
6.88	2.07	30.08	
6.85	2.06	30.07	
6.92	2.09	30.02	
6.88	2.08	30.23	7.41%
6.79	2.08	30.63	
6.95	2.08	29.93	
6.84	2.05	29.97	
7.02	2.13	30.63	
6.94	2.08	29.97	
	Average	30.23	

Table 6. Ash percent of briquettes with quicklime.

Mass of briquettes	Ash	Percent of ash	Sulphir
6.96	2.82	40.51	
6.76	2.67	39.50	
6.92	2.81	40.60	
7.02	2.91	41.45	
6.94	2.88	41.50	5.48%
7.10	2.95	41.55	
6.96	2.81	40.37	
7.00	2.90	41.43	
6.98	2.88	41.26	
6.96	2.82	40.52	
	Average	40.87	

Results and discussions

Sulphur in the Lakhra coal was determined on LECO, SC-132 as 5.6% (Table 2). Stoichiometrically, 17gm of limestone is required to trap 5.6 gm of sulphur but minimum 35gm of limestone may capture sulphur from the coal with a probability of 50%. The reaction of sulphur capture is as shown:

$CaCO_3$ Heated at 800^0C = $CaO + CO_2$

S (from coal) + O_2 (of air for combustion) = SO_2

$2SO_2 + O_2$ (of air) + $2CaO = 2CaSO_4$

Nascent calcium oxide, generated during combustion of coal with limestone in fluidised state, was found more reactive as compared to pre-prepared calcium oxide as it absorbed moisture from atmosphere. Hence, probability of formation of calcium sulphate is 50%. Average percentage of capture of sulphur in limestone as calcium sulphate was observed to be 7.41% determined in the mixture of crushed ten samples of ash of the briquettes (Table 5), compared to pre-prepared quick lime, which was 5.48% (Table 6). Limestone is, therefore, recommended over quicklime to trap sulphur of coal. Energy used for the production of quick lime CaO (separately) is saved, compared to that used for pre-prepared quicklime before briquetting. Mixing of limestone with Lakhra lignite was preferred rather than mixing quick lime and Lakhra lignite for briquetting. It was observed that arrest of sulphur with limestone was more than with quick lime.

Material Balance (with limestone)				Material Balance (with quicklime)			
Reactants (input)		**Products (Output)**		**Reactants (input)**		**Products (Output)**	
Coal	**60.0 %**	**Exhausts**	**69.77 % (loss in mass)**	**Coal**	**60.0 %**	**Exhaust**	**59.13 % (loss in mass)**
Limestone ($CaCO_3$)	**20.0 %**	**Ash**	**30.23 %**	**Quicklime (CaO)**	**20.0 %**	**Ash**	**40.87 %**
Clay	**10.0 %**			**Clay**	**10.0 %**		
Water	**10.0 %**			**Water**	**10.0 %**		
Total	**100.0**		**100.0**	**Total**	**100.0**		**100.0**

(Quantity of exhausts is determined by subtracting percent ash from100)

Conclusion

It was observed that sulphur fixation with limestone was more than quicklime CaO (Tables 5 and 6) showing 7.41% and 5.48% respectively. On the basis of sulphur content of the coal, the fixation in limestone is 43.77% and 24.24% in case of quicklime. The ash content of coal briquettes includes oxides of mineral matter of coal, clay and calcium sulphate. Exhausts 69.77% and 59.13% for compositions 1 and 2, respectively, include oxides of carbon, sulphur and particulate matter. The composition of exhaust varies from ignition to combustion as particulates (un-burnt matter) are generated due to incomplete combustion; most of energy is lost for the release of moisture of briquettes. Moisture free fuels catch fire smoothly (Ali, 2004). The exhaust becomes smokeless or colourless after ignition of briquettes. The changes in colour of exhaust from black to colourless show that combustion of briquettes has started. 1kg raw Lakhra lignite is completely burnt out within one hundred minutes while 1kg of briquettes of this coal takes more than two hundred minutes. The main reason is that the mixture of sulphur sorbent, clay and water prevents its quick combustion due to addition of binding martial and compactness. The porosity of coal is reduced in briquettes that also increases the time of combustion. Long duration of combustion of coal briquettes dilutes the concentration of oxides of sulphur in the flue. This long duration of combustion of coal briquette makes it ideal for space warming, particularly, for chicken sheds. However, it is not recommended for domestic space heating from environmental point of view. It may be allowed to provide the flue is let out to atmosphere through leak-proof chimney.

Homogenous mixing of the coal briquetting material also plays an important role on ignition/combustion and sulphur fixation. Uniform mixing depends on the type of equipment, fineness of material and length of time of mixing.

Spontaneous combustion of coal is one of the outstanding properties of coal in general and low grade coal-lignite in particular. Spontaneous combustion is the self-ignition of coal during storage, losing its energy potential. Spontaneous combustion of coal is responsible for fire in the coal fired power plants if precautions are not taken in time to arrest spontaneous combustion. It is recommended that briquetting of the coal should be done at the mining mouth just after mining to prevent spontaneous combustion. Coal briquettes could be stored for a very long time; the combustion efficiency is increased due to loss of moisture.

References

Ali, I. 1994. Coal Briquettes: Engineering Horizons, Vol. V, No. 9.

Ali, I. 1996. Coal Briquettes: An Economic and Efficient Fuel from Pakistani coal, VISION, Vol.1, No.4.

Ali, I. 2004. Energy-Conserving Stoves, Science, Technology & Development, Vol.23, No. 1.

Government of Pakistan. *Economic Survey, 1992-93.* Islamabad: Finance Division.

Perry, J.H. 1963. Chemical Engineers' Handbook 4^{th} Edition.