



ELSEVIER

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Demineralization of low grade coal – A review



Pratima Meshram, B.K. Purohit, M.K. Sinha, S.K. Sahu, B.D. Pandey*

Metal Extraction & Forming Division, CSIR – National Metallurgical Laboratory, Jamshedpur 831007, India

ARTICLE INFO

Article history:

Received 13 December 2013

Received in revised form

10 August 2014

Accepted 26 August 2014

Keywords:

Coal

Ash

Demineralization

Physical beneficiation

Chemical beneficiation

Sulfur

ABSTRACT

World over large reserves of low grade coals are available. The use of low-grade coal in various industries like power plants, metallurgical plants, cement units, etc. creates environmental pollution because of generation of large amount of solid and gaseous pollutants. Therefore, it is of paramount importance to clean the coal before its utilization. A number of upgrading technologies are being followed to produce clean coal. The current paper reviews demineralization/desulfurization of coals containing high ash and/or sulfur by physical, microwave, bio- and chemical beneficiation methods. Physical beneficiation of coal is not very effective in separation of the finely dispersed minerals, whereas microwave processing requires lesser time but is not favoured energetically. Bio-processing is mainly used for the desulfurization of high sulfur coal, although it is usually slow and requires long incubation period. Chemical beneficiation uses expensive reagents and leads to the generation of large amount of wastewater which is to be purified before discharge. Thus, a combined approach consisting of physical beneficiation followed by chemical cleaning of coal appears to have a potential for significant reduction of ash with less investment while generating less amount of wastewater.

© 2014 Elsevier Ltd. All rights reserved.

Contents

1. Introduction	746
1.1. Coal formation	746
1.2. Coking and non-coking coals	746
1.3. Mineral matters in coal	747
1.4. Global coal scenario	748
1.5. Characteristics of Indian coals	748
1.6. Demineralization/desulfurization of coals	749
2. Physical beneficiation of coal	749
2.1. Gravity separation techniques	749
2.2. Froth flotation	750
2.3. Oil agglomeration	751
2.4. Magnetic separation	751
2.5. Electro-static separation	752
2.6. Microwave processing	752
2.7. Dry fluidization	753
2.8. Limitations of physical beneficiation	754
3. Bio-processing of coal	754
4. Chemical beneficiation of coal	755
4.1. Acid leaching	755
4.2. Alkali leaching	757
4.3. Leaching of coal with alkali followed by acid	758
5. Conclusion	758

* Corresponding author. Tel.: +91 657 2345242; fax: +91 657 2345213.

E-mail address: bd_pandey@yahoo.co.uk (B.D. Pandey).

Acknowledgements.....	759
References.....	759

1. Introduction

Coal is the single largest fossil energy source used world-wide and is possibly the largest contributor to the industrial growth [1]. Coal plays a key role in electricity generation and is input to most iron and steel production, and cement units. As estimated by the World Coal Association, 70% of the world's steel production is based on coal and 41% of the world electricity generation is through coal [2]. The full utilization of coal as a resource has been limited by the presence of high levels of ash and sulfur in its major deposits. Because of the world energy crisis, rising price of crude oil and natural gas, and gradual depletion of high-quality coal reserves of the world, demineralization and/or desulfurization of low-grade coals to obtain environmentally acceptable clean fuels has attracted greater attention. Considering the limited reserves of petroleum and natural gas, eco-conversion restriction on hydro-electric projects and geo-political perception of nuclear power, coal will continue to occupy the center stage of global energy scenario [3]. Particularly in India about 55% of the current total commercial energy is met by coal and more than 75% of non-coking coal is used for power generation [4].

1.1. Coal formation

Coal goes through several changes during formation. Coal forms in swampy areas as a result of the decay of plants in the absence of oxygen. Biochemical changes produced by bacteria release oxygen, hydrogen and hence carbon content is concentrated. Coal beds consist of altered plant remains. When forested swamps die, they sink below the water and begin the process of coal formation. In swamp where coal forms, other sediments such as sand, clay and silt may also deposit. The weight of the sediment compresses the underlying organic matter. Due to the increase in pressure with time, impurities and moisture are squeezed out leaving a high carbon concentration.

There are four stages of formation of coal: peat, lignite, bituminous and anthracite. These stages depend upon the conditions under which the plant remains were subjected after they were buried – greater the pressure and heat, higher the rank of coal. Higher-ranking coal is denser and contains less moisture and gases, and has a higher heat value than lower-ranking coal (Table 1).

Peat, the first stage of formation of coal, contains a lot of water and has a fibrous, soft and spongy texture. The water content must be dried before its use as a source of heat/energy and it burns with a long flame and smoke, therefore it is generally not advised for industrial purposes. Subsequent burial of the peat results in the decrease of water content. This process normally extinguishes bacterial activity, and as temperature rises with increasing depth of burial the coalification processes begin to transform the peat to brown coal, then lignite, sub-bituminous and bituminous coal, and finally to anthracite. Lignite is dark brown in color and contains traces of plants. It is used only if no other source of fuel is available. Bituminous coal also known as soft coal with no remains of plant material is used greatly in industries as a source of fuel. Anthracite or hard coal is the final stage in coal formation and is formed due to high temperature and pressure. This type of coal has the texture of a rock and has some luster. It produces small flame and little smoke.

Coal may be classified into scientific and commercial category relating the ultimate and proximate analysis, respectively. Out of the classification suggested by International Organization for

standardization (ISO), ASTM and British Standard Institution (BSI), the most accepted one is by ASTM which is based on the proximate analysis to designate the rank and grade of coal [9].

1.2. Coking and non-coking coals

Coking coals are used for production of coke which is used in steel industries and non-coking coals are required for thermal power plants for steam production. Coking coals are hard porous substance that comprises about 90% carbon with the balance being ash (non-combustible material), volatile matter and other impurities such as sulfur and phosphorus. When coking coal is heated in absence of air, it leaves a solid coherent residue possessing metallic greyish luster and has the physical and chemical properties of the coke. The non-coking coals also leave solid coherent residue, but may not be suitable for manufacture of coke. This coal may form a coke but it will not meet the physical and chemical properties as laid down by the steel industry. It can be used in the reduction of metallic oxides to metals.

Coking coals are those coals that soften, swell and then solidify as they are heated through the temperature range 350–550 °C. By definition these coals all have a low ash content (1–10%), low permeability as determined by inherent moisture, moderate vitrinite content (to provide volatile matter) and volatile matter in the range 18–45%. The reflectance of the maceral vitrinite is also used as a measure of coals suitability for coking. Reflectance measures the amount of light that is reflected from a polished piece of vitrinite and for coking coals it is in the range 0.6–1.8% (range of bituminous coals). The coals with the lowest reflectance have the lowest rank and the highest volatile matter.

Table 1
Stages in coal formation and their properties [5].

Coalification stage	Moisture ^a (%)	Volatile matter ^b (%)	Carbon content ^b (%)	Calorific value ^a (kcal/kg)	Oxygen content ^b (%)
Peat	~75	69–63	< 60	3500	> 23
Lignite	35–55	63–53	65–70	4000–4200	23
Sub-bituminous C	30–38	53–50	70–72	4200–4600	20
Sub-bituminous B	25–30	50–46	72–74	4600–5000	18
Sub-bituminous A	18–25	46–42	74–76	5000–5500	16
High volatile bituminous C	12–18	46–42	76–78	5500–5900	12
High volatile bituminous B	10–12	42–38	78–80	5900–6300	10
High volatile bituminous A	8–10	38–31	80–82	6300–7000	8
Medium volatile bituminous	8–10	31–22	82–86	7000–8000	4
Low volatile	8–10	22–14	86–90	8000–8600	3
Semi-Anthracite	8–10	14–8	90	7800–8000	3.5
Anthracite	7–9	8–3	92	7600–7800	4.5
Meta-Anthracite	7–9	8–3	> 92	7600	5

^a As received basis.

^b Dry ash free basis.

Download English Version:

<https://daneshyari.com/en/article/8118627>

Download Persian Version:

<https://daneshyari.com/article/8118627>

[Daneshyari.com](https://daneshyari.com)