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Desulphurization of Ultrafine Egyptian Coal by Semi-Coking &Wet High Magnetic Separation

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ABSTRACT

A combination of semi-coking followed by wet high intensity magnetic separation has been used for the upgrading of El-Magara ultrafine Coal. The samples were semi-coking at 550°C and then upgraded by the wet high intensity magnetic separator. Semi-coking of ultrafine coal decreases energy costs for its crushing and significantly increases magnetic properties of its mineral constituent. The factors effects on the processes were studied such as feeding rate, solid/liquid ratio and magnetic field intensity. The semi-coking coal in the size range of −25µm with pyrite feed contains 2.1% was used for this study. At the end of this study the sculpture content decreased from 2.1 % to 0.45%.

Introduction

Coal is the most abundant fossil fuel. It supplies about 42% of electricity for the world [1]. Due to mechanize mining methods, the fine coal increases gradually [2]. The fine coal has high sulfur content and its direct combustion will seriously pollute the environment and destroy ecological construction, there are many methods for desulfurization of coal each one depends on the ore nature [3, 4]. Low ranks and fine coals always contain very high moisture, ash, and sulfur contents. So recovery of fine coals has economic and environmental benefits [5, 6, 7, 8, 14].

Semi-coking considered the best method for the desulphurization of the fine coals because it activates the organic and pyrite sulfur in the coal and transforms them into paramagnetic form can be collected by magnetic separator. Also it was found that the treating of low-rank coals at temperatures above 450 °C reduced not only the pyritic sulfur but also the organic sulfur in coal. The lignite was carbonized and the pre-heated low rank coals could be separated effectively by a dry permanent magnetic roll separator. Both the total sulfur and organic sulfur could be rejected into the tailings [1, 9, 10, 11, 12, 13].There are many forms of sulfur in coal can be summarized in figure 1 [3]. Also, There are different techniques can be used in pre-combustion desulphurization of coal summarized in Figure 2 [2].

This article aims to study the feasibility of decreasing total sulfur content in ultrafine El-Maghara Egyptian coal using semi-coking method followed by Wet High Gradient Magnetic Separation (WHGMS).

2. Materials and Methods

2.1. Sample Preparation

The run-of mine coal of -50 mm in size was reduced to 1mm by jaw, cone and roll crushers in sequence followed by a pulverizer to prepare sample with -0.053 mm. The sample, however, was ground to -25 µm by means of a laboratory scale planetary micromill (2 positions) supplied from FRITSCH Company, Germany. The samples were stored in sealed bags and kept refrigerated.

2.2. Semi-coking Process

The representative samples were subjected to the same constant conditions prior to the treatment of the magnetic separator. The different operating conditions affecting the process were studied. In this method 50 g of coal was placed into porcelain crucible and then heated up to 350 350 °C in closed muffle furnace for 15 min.The total sulfur (organic and inorganic) were converted into magnetic pyrrhotite form which can be easily picked up using wet high intensity magnetic separator after studying the effect of different operating factors on the separation operation .

2.3. Wet High Gradient Magnetic Separation Technology

Different concentrations of the fine coal sample were prepared by mixing 50 g of the semi-coked samples of coal with proper amount of water to reach the desired concentration and 1 kg/t sodium silicate as a dispersing agent. The sample slurry was kept at a fixed continuous agitation during the separation using IKA Eurostar digital (Labortechnik) agitator at 1000 rpm. The sample slurry was pumped up-wards to the laboratory "Boxmag Rapid" separator at different feeding flow rates using "Master flex-model 7518-00" peristaltic pump. The separation was operated at different magnetic field intensities up to 14000 gauss. When the coal slurry sample completely passed through the canister box, the steel wool was washed with fixed amount of water at constant rate throughout all the tests. After washing, the nonmagnetic clean coal product was collected. Then the separator was off and the magnetic fraction was then collected by flushing water until the effluent was clear. The magnetic fraction was then collected, dewatered and dried. All products were weighed and chemically analyzed for total sulfur. The gradient magnetic field of wet high gradient magnetic separation technology is obtained by filling the magnetic field space with stainless steel wool with high magnetic conductivity, when the fine coal passes through the magnetic separator, the paramagnetic particles such as pyrite were picked up on the filled stainless steel wool filter, while the diamagnetic coal will pass through

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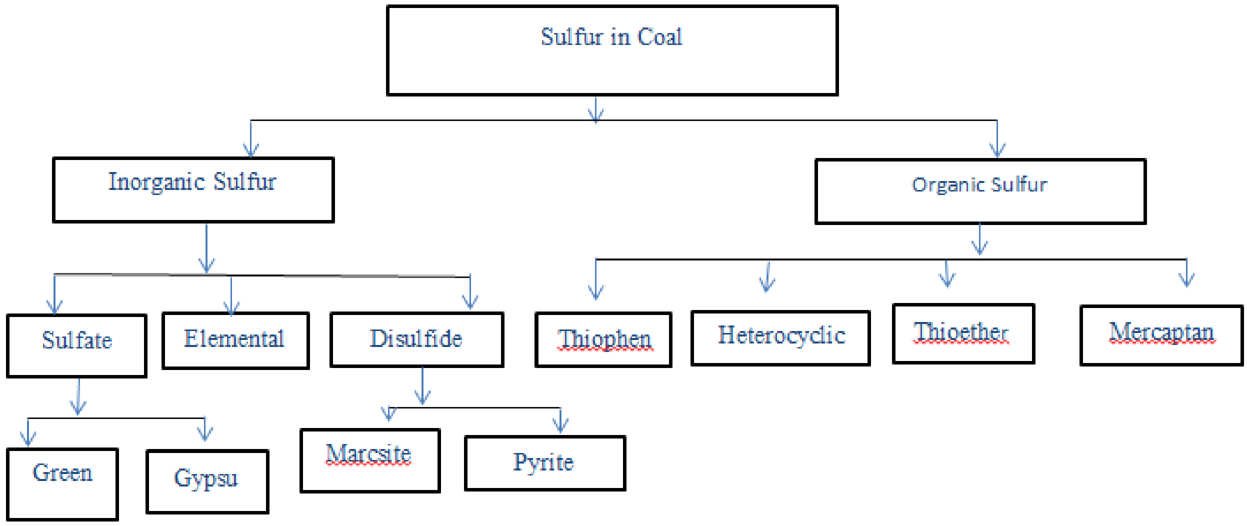

Figure1. Forms of Sulphur in coal

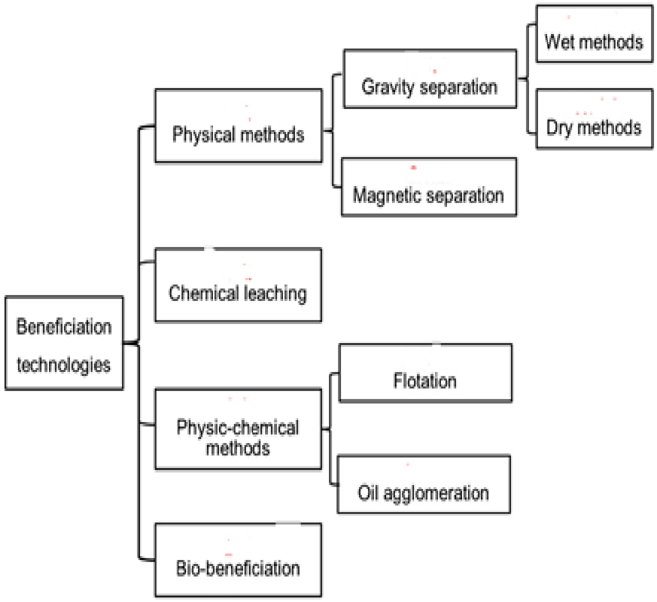

Fig 2. Suggested flow sheet to beneficiate the low-rank coal

the separator smoothly, thus realizing the separation of pyrite coal. The magnetic force *Fm* of a magnetic particle in a magnetic field can be expressed as follows:

$Fm = X \cdot V \cdot H \cdot dH/dX$,

Where X is the magnetic susceptibility of a magnetic substance; V is the volume of the particle; H is the magnetic field intensity; and dH/dX is the magnetic field gradient.

The factors effect on the process were studied such as feeding rate, sold/liquid ratio, magnetic field intensity and the non- magnetic particles were considered as a concentrate, and magnetic as a tail.

Fig 3. Boxmag rapid WHIMW magnetic separator.

3. Results and Discussion

3.1. Sample Characterization

Petrography of the coal sample showed that the coal is dominated by amber-like resinite in amatrix of desmocollinite (fine vitrinite) andliptodetrinite (detrital liptinites). Other macerals do occur, such as semifusinite and telocollinite, Figure 1. The Complete characterization of El Maghara coal was carried out in table 1.

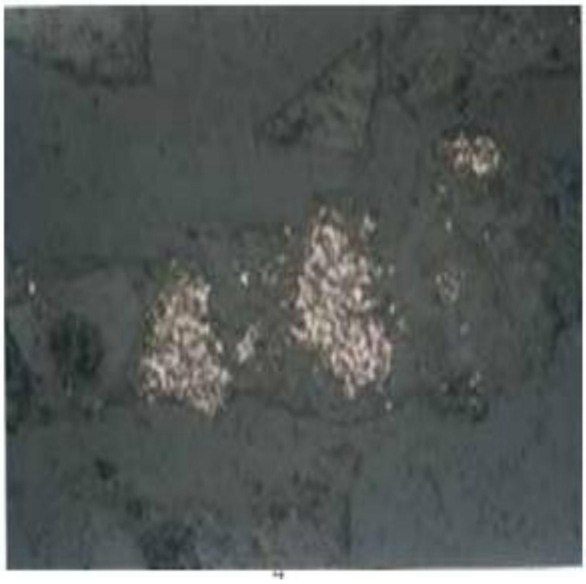

Figure 4. Original Coal sample (coal is green and pyrite is yellow)

Table 1. The chemical analysis of El Maghara coal sample on dry basis

Constituent	Wt.
Moisture %	1.63
Ash %	10.13
Volatile matter %	49.15
Fixed carbon%	38.61
Total sulfur %	3.30
C %	52.86
H %	11.67
N %	1.05
Pyritic sulphur	1.5
Degree of oxidation %	0.022
Upper calorific value, cal/kg	13,205

3.2. Upgrading of fine coal Using WHIMS

3.2.1. Factors Effect on the Sulphur Content Removal

3.2.1.1. Effect of Solid/Liquid Ratio:

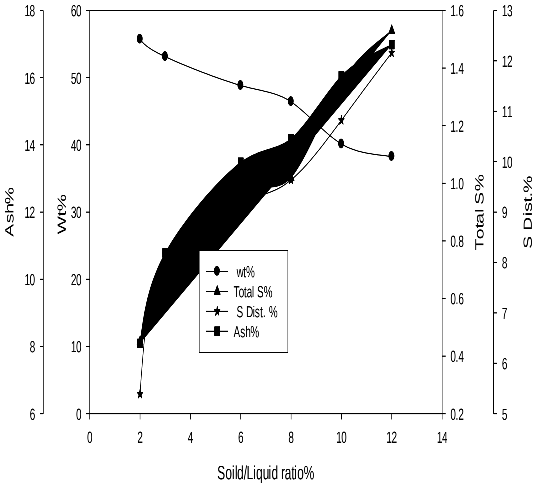

Figure 5. Effect of solid/Liquid ratio, on the removal of total Sulphur from the Egyptian coal sample.

Figure 5 shows the effect of Solid/liquid ratio on the total sulphur removal during wet magnetic separation after semicoking of the sample where with increasing the solid % the weight percentage of the non-magnetic fraction decrease in the same time, the Sulphur distribution increase from 2% to 12%, and the total Sulphur % increase from 0.45% to1.53 % . This may be related to low % of particles. the magnetic particles picked up easily to the field and the Sulphur increase in the magnetic fraction (tail) and decreased in the non-magnetic (concentrate) with increasing the S/l ratio the particles aggregated and form more than one layer of particles and non-magnetic particles coat the magnetic particles this perform to increase Sulphur in the non-magnetic fraction.

3.2.1.2. Effect of Feeding Rate on the Removal of Sulphur from the Egyptian Coal

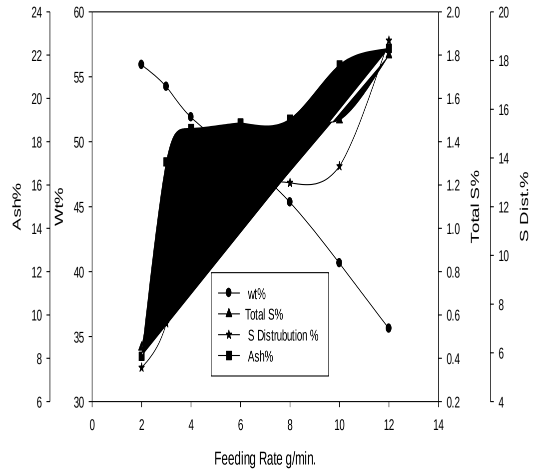

Figure 6. Effect of feeding rate on the removal of total Sulphur from the Egyptian coal sample.

From figure 6 with increasing the feeding rate the total Sulphur and Sulphur distribution increase in the non-magnetic fraction where the total Sulphur increase from 0.45% at feeding rate 2 gm/min. to 1.80 % at feeding rate 12 gm/min. ,also the distribution of sulphur increase from 5.39 % to 18.82 % (non-magnetic fraction).This due to low speed of particles increase the chance of the pyritic particles to attack the magnetic field and easy picked up but with increasing the particles speed the magnet cannot capture particles because of the particles speed and the Sulphur increase in the non-magnetic fraction, this is in agreement with [18].From these results the best feeding rate at 2 gm/min.

3.2.1.3. Effect of Magentic Field Intensity on the Separation of Sulphur from Coal

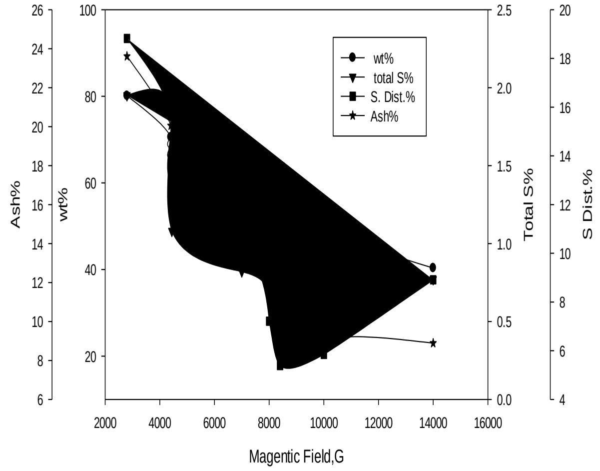

Fig7. Effect of feeding rate on the removal of total Sulphur from the Egyptian coal sample.

From figure 7, increase the magentic field the paramagnetic pyrite particles attched easily to the magnetic field in the same time decrease wt% of the non-magentic fraction and the total sulphur and sulphur distribution decrease in the non-magnetic fraction (concentrate) and total sulphur decreased from 1.95 at 2800 G %to 0.45%at 8400 G and its distribution from 18.82% to 5.39% respectively. The increase of magnetic intensity the attached particles to the field increase after field intensity 14000G significant increase in the total sulphur occurs. The best results were obtained at 8400 G. the SEM of the final concentrate after semicoking and wet high magnetic separation in figure 10.

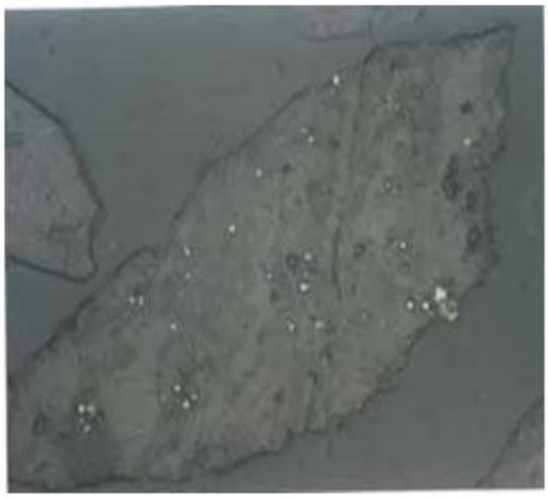

Figure 10. SEM of the Final concentrate of the ultra-fine El- Maghara coal Sample

4. Conclusions

The Egyptian fine coal is of low grade containing high volatile matter, and high Sulphur content could not be used in the power stations, because of the air pollution and environment restrictions. The semi-coking of the ultrafine coal followed by wet high magnetic separation the mild temperature not only activates the pyrite Sulphur but also, the organic Sulphur in the coal. The separation of wet high intensity magnetic separation lower the Sulphur content from 2.10 in the origin sample to 0.45% in the final concentrate at optimum conditions of 8400G magnetic field intensity, 2gm/min. feeding rate and 2% solid/liquid ratio. The results showed that semi-coking followed by magnetic separation is very effective and economic.

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