The improvement of quality of coal using magnetic separation

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The possibility to extract iron from coal in order to decrease sulphure content is that to use the high gradient magnetic separation method and superposed magnetic field gradients. Constructive details, characteristics of the high gradient magnetic separation installation used, theoretical and experimental data are presented in this paper.

Key words: separation, high gradient magnetic field, coal.

1. INTRODUCTION

It is well known that coal contains compounds of the sulphur from which after burning is obtained SO₂ very dangerous for pollution of atmosphere because may favors acid rains. The sulphur extant in ore of coal may be eliminating using a magnetic method of separation [1, 2, 3, 4]. The High Gradient Magnetic Separation method has been used in order to eliminate sulphur from ore of coal. Some theoretical and experimental data will be shown in this paper.

2. THEORETICAL CONSIDERATIONS

The High Gradient Magnetic Separation method consists in passing through a ferromagnetic matrix of a biphasic fluid which contains dispersion of magnetic and nonmagnetic grains in mixture which have to be separated.

It is well known that a magnetic or magnetizable particle characterized by magnetization

\[ \tilde{M} = \chi \tilde{H} \]  


where $\chi$ is magnetic susceptibility of the particle and $\vec{H}$ is magnetic intensity of the field is acted by a force given by relation:

$$\vec{F} = \mu_0 V (\vec{M} \cdot \vec{\nabla})\vec{H}$$

where $V$ is volume of the particle and $\mu_0$ is magnetic permeability of the vacuum.

The effect of separation will be better if $(\vec{H}\vec{V})\vec{H}$ has a higher value. Because the increase of the $H$ is technical limited the solution is to increase value of the $\vec{V}$. That means high gradient of the magnetic field, which may be achieved using randomized thin ferromagnetic wires, so called "magnetic wool" positioned in separation chamber between polar shoes. In these conditions we obtain near wire on a short distance high variation of the intensity of magnetic field.

The magnetic wool is used especially in order to retain from mixture of ore the magnetic particles having diameter equal or less that of the magnetic wool.

In order to reduce matrix saturation the chamber containing magnetic wool will have a placement in gradient of magnetic field between polar pieces. In this way near wire of magnetic wool will be in fact superposed magnetic field gradients.

### 3. EXPERIMENTAL DEVICE AND PROCEDURE

Schematically shown in Figure 1, the experimental device consists of an electromagnet – 1, having coils – 2 and polar pieces – 3 which ensures magnetic field characterized by a vertical gradient having the same orientation as gravitational acceleration.

[Diagram of experimental device]

Fig. 1 – High gradient magnetic separation installation; 1 – electromagnet, 2 – coils, 3 – polar pieces, 4 – movable chambers, 5 – cable, 6 – motor, 7 – mechanical transformer, 8 – vessel for collection.
The chambers 4 containing magnetic wool execute an alternating linear movement between polar pieces of electromagnet. The train of device consists in cable 5, motor 6 and mechanical transformer 7. The vessel 8 for collection ensures separate reception of the pure coal and of the magnetic inclusions which contain sulphur.

The technical characteristics of the device are: electrical tension on coils U=60V, intensity of the electric current in coils I=5A, magnetic induction B=0.5T, speed of the movable chambers \( v=3\cdot10^{-2}\) m/s and power of the motor \( P=0.5\) kW.

The feed of the installation with coal is in continuum flux and washing of the magnetic wool is achieved out of the magnetic field by a current of water under pressure so that magnetic wool to be clean when enters between polar pieces.

### 4. EXPERIMENTAL RESULTS

The samples used have been taken from processing flux of the coal, after separation by flotation method. Experimental results are based on differences between magnetic properties of the coal, which is diamagnetic, and that of the associate impurities as pyrites and chalcopyrite, which are paramagnetic and contain sulphur. The installation used for experimental measurements had between polar pieces in central region a middle value of the magnetic gradient \( |\nabla H|=4\) T/m. The magnetic wool positioned in this region ensures near magnetic wire \( B_w=0.8\) T and an high gradient of the magnetic field \( |\nabla H_w|=2\cdot10^4\) T/m, sufficiently to obtain a very good collection of the magnetic or magnetizable particles from area of coal on the magnetic wires.

The experiments have been made using special coil (ash up to 12%) and mixture coal (ash between 20% and 30%) from Jiu Valley. The ash obtained after burn of coal contains impurities as pyrites, chalcopyrite, sands, clay and oxides of Na, Mg, Al, Si, P, K, Ca and so on. The content of the ash have been obtained in laboratory of the preparation plant using chemical methods having accuracy of 0.01%. The results are shown in the next table.

<table>
<thead>
<tr>
<th>Type of sample</th>
<th>Ash initial concentration (%)</th>
<th>Ash final concentration (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Special coal</td>
<td>8.5</td>
<td>8.1</td>
</tr>
<tr>
<td></td>
<td>12.1</td>
<td>11.1</td>
</tr>
<tr>
<td>Mixt coal</td>
<td>24.4</td>
<td>23.2</td>
</tr>
<tr>
<td></td>
<td>30.2</td>
<td>28.1</td>
</tr>
</tbody>
</table>

The diminution of the ash in coal using this method of magnetic separation is a little, but is that which contains sulphur. The contribution of the pyritic sulphur in ash initial concentration have been up to 1.3% for special coal up to 2.5% for mixte coal. In fact is a desulphuration of the coal, very imported for its quality.
REFERENCES