INVESTIGATION OF SOME PHYSICAL PARAMETERS ON OIL AGGLOMERATION OF COAL

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Abstract

The effects of some physical parameters on oil agglomeration were investigated in this study. The size of the stirrer palettes, cell shape and barrier number were chosen as the physical parameters. Agglomeration experiments were carried out at a certain solid-liquid ratio (0.01 g/cm^3), at 1500 rpm of stirring speed and the natural pH of the suspension with 2 mL of kerosene. Thirty different experiments were conducted for oil agglomeration of coal. The high agglomerate yields with high combustible recovery were obtained. The ash removal of coal was about 20%. As a result, it has been shown that the physical conditions originating from the experimental design are effective in the success of the oil agglomeration.

Keywords: *oil agglomeration, coal, physical factors, kerosene.*

1. INTRODUCTION

Oil agglomeration method is a very effective method for recovery of fine-sized minerals. High yield and selectivity are the main advantages of this method. (Mehrotra, 1983, Yoon, 1991, Yamik et al., 1994, Hacifazlıoğlu, 2008). The difference of surface properties of coal and other minerals are utilized for the effective separation. In this process, a second liquid (usually oil) is added in the suspension. This oil wets the hydrophobic coal surfaces selectively by spreading on the surfaces (Laskowski, 2000). The oil wetted coal particles adhere to each other and grow in size by mixing of suspension at the appropriate velocity (Capes, 1980; Laskowski, 1992). This is due to binding property of the oil (bridging fluid) to the hydrophobic surfaces. Other hydrophilic minerals remain suspended in the dispersed state in the suspension. The resulting structure is called agglomerate and have a spherical shape. These agglomerates which have grown in size are easily separated from the inorganic part by a sieve of appropriate size.

There are many parameters such as hydrophobicity of mineral, type and amount of oil, mixing speed and time, pH, solid ratio, particle size and solid concentration of suspension affect the oil agglomeration method (Capes and Darcovich, 1984; Garcia, 1998; Abakay et al., 2004, Duzyol, 2015; 2016a; 2016b).

However, it is believed that some physical parameters other than these variables will affect the oil agglomeration process. There has not yet been any work related in this topic in the literature. For this reason, the effects of some physical parameters on the oil agglomeration of coal have been examined in this study.

2. MATERIALS AND METHODS

2.1. Materials

The coal sample obtained from Zonguldak/Karadon region was used in the experiments. The sample was prepared to appropriate size for oil agglomeration by crushing and grinding. The coal sample had high hydrophobicity and the moisture and ash content of coal were 17.8% and 16.4%, respectively. The agglomeration experiments were conducted at natural pH of suspension and mono-distilled water was used. Kerosene was used as binding liquid.

The size of the stirrer palettes, cell shape and barrier number were chosen as the physical parameters. Other operation parameters affecting oil agglomeration were kept constant to determine the effect of the

selected parameters. 1000 mL volume of cylinder and rectangular shaped of two different test cells were used. The stirrer palettes tips were selected in three different sizes, small, medium and large.

In oil agglomeration, it is important that the particles come together to compose the agglomerate form. That is, it is necessary that the coal particle and the oil droplets should be close enough to each other (Kilinc et al., 2010). The turbulence created during the mixing of the suspension will reduce the likelihood of collision of the particles. For this reason, glass barriers of different numbers and positions were placed in both types of cells. All materials preparing for this aim were seen in Fig 1.



Figure 1. Stirrer palettes and cells with barriers

2.2. Methods

Ten milligram of coal sample prepared in the size of -106 + 53 μm size fraction was used in the oil agglomeration experiments. The solids ratio of suspension was kept constant at 10/1000 (w/v). The test parameters were also kept constant at 2 mL of kerosene, stirring speed of 1500 rpm and agitation time of 5 min.

At the beginning of the agglomeration experiment, coal and water were mixed to provide a well dispersion of the sample in the selected test cell. Then, kerosene was added and stirred for 8 minute. At the end of the agglomeration time, the obtained agglomerates were poured into the test sieve (-212 micrometer) and washed with tap water. Thus, the agglomerates were separated from the non-agglomerated particles.

The agglomerates remaining on the sieve were collected on the filter paper, filtered and dried, then weighed to determine the weights of the agglomerates. After the ash content of agglomerates was determined, the combustible recovery (CR, %) was calculated by using Equation 1.

$$\text{Combustible Recovery (CR, \%)} = \frac{A(100-A_{ash})}{F(100-F_{ash})}\mathbf{100} \qquad [1]$$

Where, A; the percentage of agglomerate, F; the percentage of feed, A_{ash}; the ash content of agglomerates, F_{ash}; the ash content of feed.

3. RESULTS AND DISCUSSION

In the agglomeration experiments two types of cells were used, square and cylindrical. Several numbers of barriers (2,4 and 6) were placed into the interior surface of cells to be equally spaced and equal in size. At the same time, two different experimental cells have been prepared. One of them had no barrier and the other had barriers which placed randomly. 30 number of oil agglomeration experiments were carried out using three different stirrer palettes and the resulting results were given in Table 1. In Table 1, it was observed that when the rectangular shaped test cell was used, the negative effect on the efficiency of agglomeration with increasing the number of barriers. Moreover the CR values of the agglomerates obtained from the cells without barrier were found to be higher. It is assumed the reason of that was because the cell was corned and therefore the possibility of collision was realized at the cell corners. It is also estimated that this environment was deteriorated by using barriers.

It seems that the size of the agitator pallet tip was also important. It must be draw attention that the CR values of the agglomerates obtained when using small tips were low. However, the ash contents of agglomerates obtained from experiments using pallets of all sizes were not changed much.

In experiments using cylindrical test cells, the increase in the number of barriers has shown a positive effect on both ash removal and CR values of agglomerates. Particularly in experiments where the number of barriers was 6, the best results were obtained. This can be considered to be due to the increased likelihood of collision by using a large number of barriers in the cylindrical cell. It was also been determined that the CR values of obtained agglomerates were not high when using the small size palettes.

Table 1. The effect of some physical parameters on the CR and ash content of coal.

Cell shape	Barrier circumstance	Size of the stirrer palettes					
		Small		Medium		Large	
		Ash, %	CR, %	Ash, %	CR, %	Ash, %	CR, %
rectangular	no	**11.9**	**77.4**	**12.5**	**93.8**	**12.8**	**97.9**
	2	12.4	70.7	13.8	93.2	13.3	100
	4	13.9	61.3	13.5	94.8	12.5	76.7
	6	12.9	67.3	12.6	91.2	12.2	71.4
	random	14.3	67.6	13.9	89.8	12.2	89.3
cylindrical	no	13.9	58.4	16.6	93.2	17.0	68.6
	2	14.3	59.3	13.0	93.3	12.6	90.2
	4	11.4	57.0	14.3	96.2	12.4	90.9
	6	**11.5**	**77.5**	**13.3**	**93.3**	**12.5**	**93.2**
	random	13.6	57.0	13.3	90.6	12.8	68.1

4. CONCLUSIONS

The aim of this study is to investigate the effect of some physical parameters such as cell shape, number of barriers and size of the stirrer palettes for oil agglomeration of coal. The following results are reached;

In suspension, the oil droplets and the dispersed coal particles should be come together to spreading of oil on the coal surface. The oil coated coal surfaces must be come together to forming the agglomerate structure. To achieve this aim, proper physical conditions must be established.

There is no need to use the cell with barrier when a rectangular shaped test cell is used. However, when using a cylindrical test cell, the maximum number of barriers must be placed into the interior surface of cell.

If the agitator is chosen having small size of the stirrer palettes, agglomerate yield will have affected negatively. For this reason, a tip of at least medium size of the stirrer palettes should be selected.

The best results were achieved when using rectangular shaped of cell with six barriers and large size of the stirrer palettes.

Some physical parameters, as well as the experimental parameters (oil type and quantity, mixing time and speed, pH, particle size, solid ratio etc.), are also effective in the oil agglomeration.

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