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Flyash Beneficiation By Air Classification

By:

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1. Introduction

In 1992, 48 million tons of flyash (not including bottom ash, boiler slag and FGD material) was produced in the United States, according to the American Coal Ash Association. Of this amount, 27.2% was utilized; although the percentage of flyash utilized increased from 20% in 1980, there is significant potential to increase utilization. One of the primary driving forces behind increased utilization is increased disposal costs due to more stringent environmental controls and regulation.

Flyash is classified as a natural pozzolan and finds significant use as a cement additive. It has been found to increase the plasticity of the cement mixture while lowering the amount of mix water needed. In addition to improving leveling and finishing properties, flyash improves pumpability as well as decreases the heat of hydration of the concrete mix which is particularly important in massive concrete structures such as dams where the concrete needs to cool as quickly as possible.

The Loss on Ignition (LOI) of flyash is an important quality when considering utilization. The LOI is primarily due to the presence of unburned carbon. The standard specifications for the use of flyash as a mineral admixture in Portland cement concrete are given in ASTM C618-89a. which sets an LOI limit of 6%; however, many states have set a more stringent limit of 3%. The primary reason for the lower LOI specification is that carbon adsorbs air, entraining agents which limit freeze-thaw resistance. This is particularly important in climates such as the mid-western U.S. where multiple cycles of freezing and thawing are typical in winter.

In order to comply with the NOx emission limits set by the 1990 Clean Air Act Amendment, many utility burners have converted to low NOx burners, with the unfortunate consequence of increased LOI content of the flyash produced by many of these burners. In many cases, flyash that was once sold as a cement admixture must now be impounded due to increased LOI content. Flyash produced as a byproduct from pulverized coal combustion presents a significant challenge to mineral processing. In order to regain a market for high LOI flyash, an effective means of removing carbon must be developed. Air classification is one process that has shown significant potential and is the subject of this paper.

2. Experimental

2.1 *Sample Preparation and Analysis*

Approximately 600 pound samples of Class F flyash were collected from several coal fired PC boilers in the eastern United States. The samples were collected over a one week period during normal operation to ensure that the flyash was representative. The composite samples were thoroughly mixed at the Center for Applied Energy Research (CAER) using a V-blender to prevent size segregation. A representative sample of each composite was obtained by riffling for size analysis while approximately 400 pounds of each composite sample was shipped to Marsulex Environmental Technologies (MET) (formerly GE Environmental Systems) for classification tests.

After completion of classification tests, all samples were returned to CAER where they were again thoroughly mixed to obtain a representative sample of each by riffling.

Size analyses were determined by wet sieving using 100, 200, 325 and 500 mesh screens. The individual size fractions were separately dried, weighed and analyzed for carbon content by direct measurement with a LEECO C-H-N Analyzer. Prior to measurement of carbon content, size fraction samples were pulverized to minimize sampling error. A summary of size and carbon analyses is presented in Table 1. Note that the size distribution and carbon content of individual size fractions of both samples GR and SP were quite similar; however, there were significant differences in how the carbon was distributed. The GR sample contained more carbon (4.88% vs. 3.28%) and more of the carbon was present in the coarser size fractions. For example, 58.9% of the carbon in the GR sample was in the +200 mesh size fraction, while for the SP sample, the same size fraction contained 42.4% of the carbon. The finest fraction (-500 mesh) of the GR sample contained only 16.58% of the carbon while the SP sample contained 29% of the total carbon present. These differences in the carbon distribution had a pronounced effect on the separation achieved by air classification.

2.2 *Air Classification Tests*

Air classification tests were conducted by Buell in Lebanon, PA, using a Model C18-9 centrifugal classifier shown in Figure 1. The orifice ratio was held constant at 0.35 while the classifying air was also fixed at 900 cfm. The feed rate varied from 1.43 to 1.97 tph while the primary variable that was changed was the amount of secondary air that was added. Once the classifier was operating under steady state conditions, representative samples of the feed, coarse and fine products were obtained and shipped by CAER for analysis.

3. Results and Discussion

The effect of increasing the amount of secondary air on yield (weight % reporting to fines) is shown in Figure 2. For both samples, the yield increased with increasing secondary air. For sample SP, increasing the secondary air from 5.22 to 11.22 increased the yield from 60.9 to 77.0%; while for sample GR, the yield was increased from 50.0 to 63.1% as the secondary air was increased from 3 to 9.5%. Analysis of the fines product generated from each test is shown in Figure 3. For the SP sample, a product was produced within specification (<3.0% C) for all the amounts of secondary air evaluated. The lowest grade obtained was 2.85% C with 5% secondary air. The corresponding yield was 60.9%. At higher levels of secondary air, the carbon content of the fines increased to 2.9% carbon while the yield improved to 77.8%. For the GR sample, a product was produced within specification with 3% secondary air (2.94% C) with a yield of 50%. Higher amounts of secondary air produced higher yields, but also increased the carbon content of the fines to above 3%.

The carbon reduction achieved with both samples is summarized in Figure 4 which shows that the GR sample provided more significant carbon reduction. This is not surprising since the carbon contained in this sample was coarser, as shown in Table 1. Despite achieving higher levels of carbon reduction, the actual grade of the fines produced with the GR sample was higher which is attributed to the higher carbon grade of the feed material (4.88% C vs. 3.28% C).
Classifier efficiency was determined for 100, 200, 325 and 500 mesh separations with the SP sample. Efficiencies were calculated using the formula:

$$efficiency = \frac{c(f-t)}{f(c-t)}$$

where c is the weight % finer than the desired size in the fines, f is the weight % finer than the desired size in the feed and t is the weight % finer than the desired size in the coarse product.

Classifier efficiencies are shown in Figure 5. In general, as the amount of secondary air was increased, the classifier efficiency also increased. At the desired split of 200 mesh, the highest classifier efficiency was 85.2% when 11.22% secondary air was used. The classifier was more efficient for finer separations (325 and 500 mesh) than for coarser separation (100 mesh).

4. Conclusions

The results obtained in this study show that the centrifugal classifier is capable of producing a product within carbon specification (<3.0%) for both samples at low amounts of secondary air. More favorable yield was obtained with the SP sample under these conditions. At higher amounts of secondary air, the results obtained with the SP sample increased slightly but were still within spec, while those obtained with the GR sample were above spec. The lower carbon content of the fines produced with the SP sample is attributed to both the lower carbon content of the feed and higher classification efficiency for the fine fractions.

Test results show that the centrifugal classifier is capable of making a 200 mesh split on the SP sample with an efficiency (85.2%). It is particularly noteworthy that both classifier efficiency and yield increase with % of secondary air. Additional testing is recommended to determine if further increasing the secondary air will improve performance. It is also recommended that additional testing include changing other operation variables to reduce the carbon content of the fines to a lower level.

5. Figures and Tables

Table 1 - Size and Carbon Distribution of Flyash Samples

Sample	*Size Fraction (Mesh)*	*Weight %*	*Cumulative Wt. %*	*%Carbon*	*Carbon Distribution (%)*	*Cumulative Carbon Distribution (%)*
GR	+100	5.26	5.26	28.33	30.56	30.56
	-100+200	11.92	17.18	11.61	28.37	58.93
	-200+325	12.96	30.14	4.97	13.20	72.13
	-325+500	14.84	44.98	3.71	11.29	83.42
	-500	55.02	100.00	1.47	16.58	100.00
		100.00		4.88	100.00	
Sample	*Size Fraction (Mesh)*	*Weight %*	*Cumulative Wt. %*	*%Carbon*	*Carbon Distribution (%)*	*Cumulative Carbon Distribution (%)*
SP	+100	2.17	2.17	31.26	20.70	20.70
	-100+200	9.26	11.43	7.66	21.70	42.40
	-200+325	12.29	23.72	3.80	14.30	56.70
	-325+500	18.09	41.81	2.58	14.30	71.00
	-500	58.19	100.00	1.64	29.00	100.00
		100.00		3.28	100.00	

Figure 1 - Schematic Diagram of the Buell Model C 18-9 Centrifugal Classifier

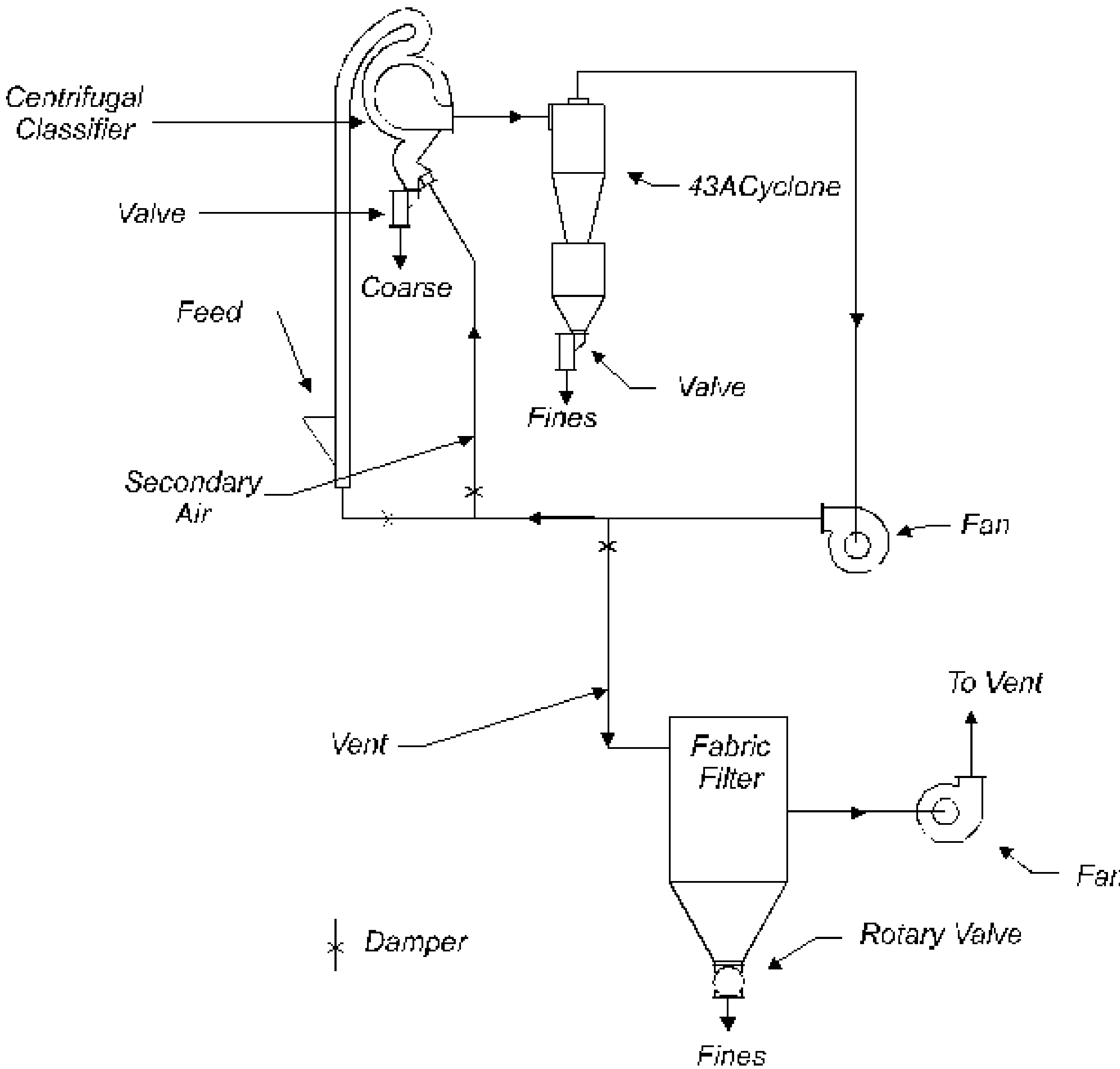

Figure 2 - Effect of % Secondary Air on Yield

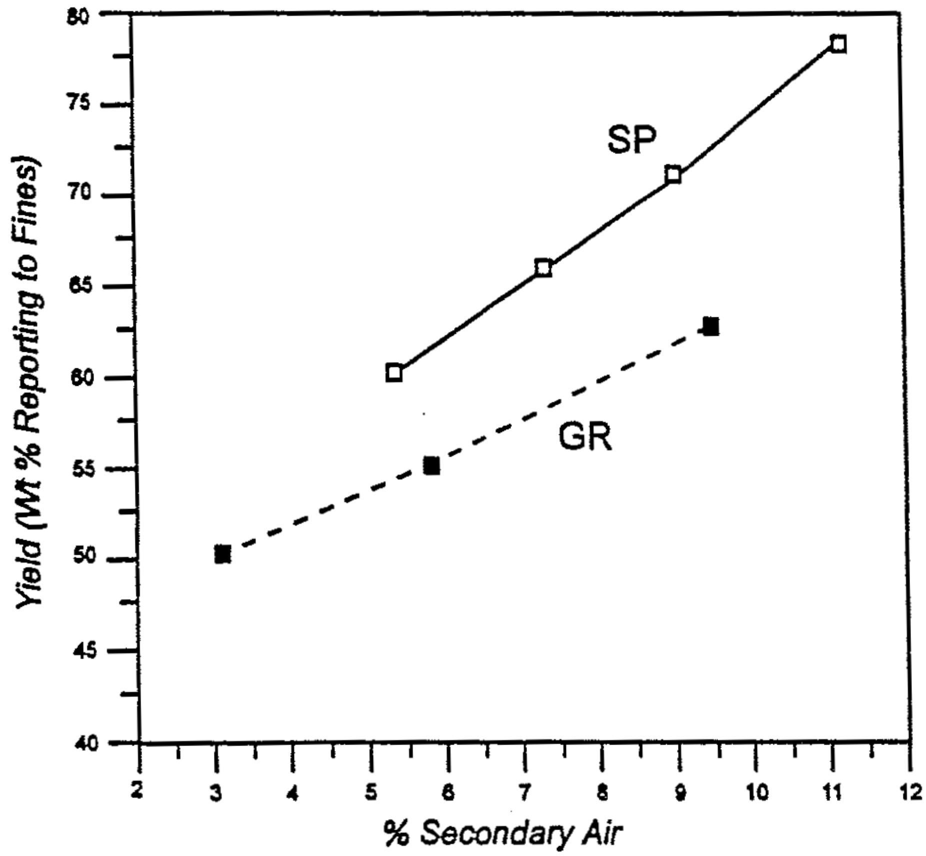

Figure 3 - Effect of % Secondary Air on Carbon Content of Fines

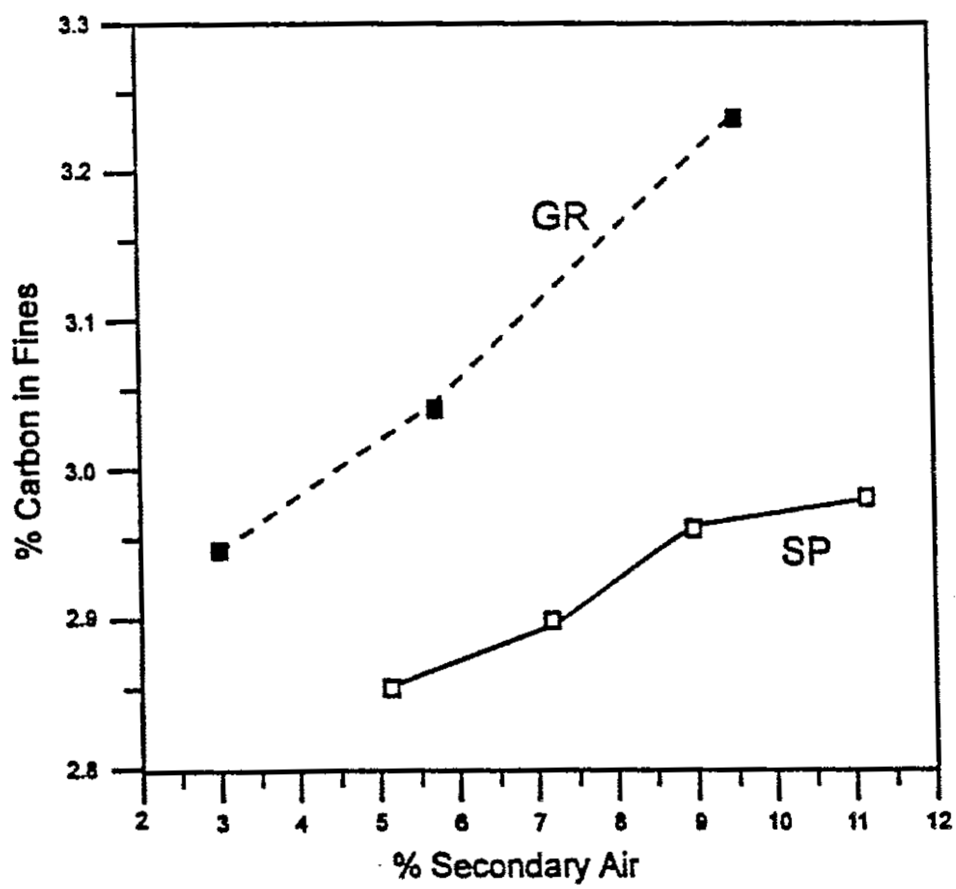

Figure 4 - Effect of % Secondary Air on Carbon Reduction

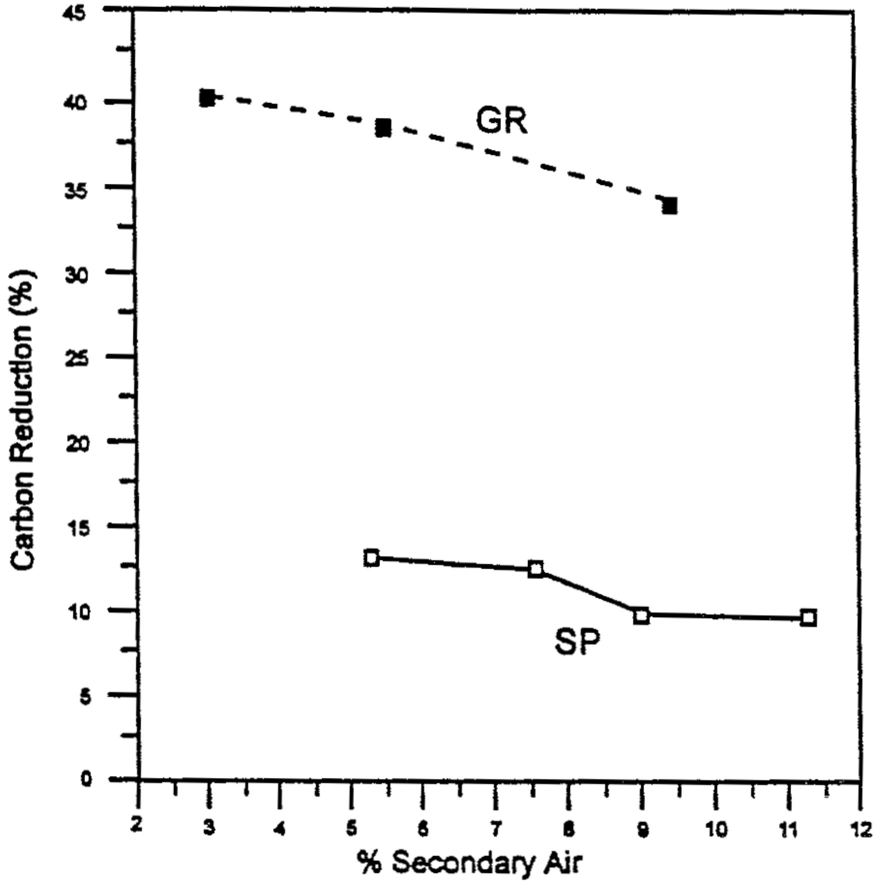

Figure 5 - Effect of % Secondary Air on Classifier Efficiency for 100, 200, 325 and 500 Mesh Separations