Sensible removal of Arsenic and Mercury from pulverized coal -Pre-Combustion-

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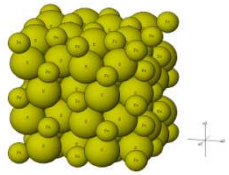
Iron pyrite (FeS2) is commonly found in coal (especially bituminous.) Trace element atoms such as arsenic and or mercury can substitute for iron atoms in the pyrite crystalline lattice



Alabama Power's Greene County Plant personnel performed an operational test on two side by side mills to determine the impact of optimized operation of the pulverizers on the reduction of trace elements such as mercury and arsenic through the removal of pyrites early in the primary classification process. Mill "A" was retrofitted with a non-OEM rotary throat and mill "C" was operated with an OEM throat.

Plant personnel took twice daily samples from November 19 to December 18, 2009. Twenty five one-hour snapshots of samples and measurements of coal feed rate, inorganic collection box contents, air flow and operating parameters for mill "A" and "C".

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CONSOL Energy Research and Development was chosen to analyze the contents of the material collected in the inorganic collection box of each mill.

- **Carbon and sulfur were used as analytical markers for coal and pyrites in the samples.**
- **Sulfur was <u>not</u> determined using ASTM D4329. Rather the pyrite samples were digested with acid and measured by inductively coupled plasma atomic emission spectroscopy. (ICPAES)**
- **Arsenic, lead and antimony were determined by ASTM D6357. Acid digestion of the inorganic material followed by determination of the elements by inductively coupled plasma mass spectrometry. (ICPMS)**
- **Mercury in the mill reject samples was determined using acid digestion of the sample followed by measurement of the mercury by atomic fluorescence spectroscopy.**

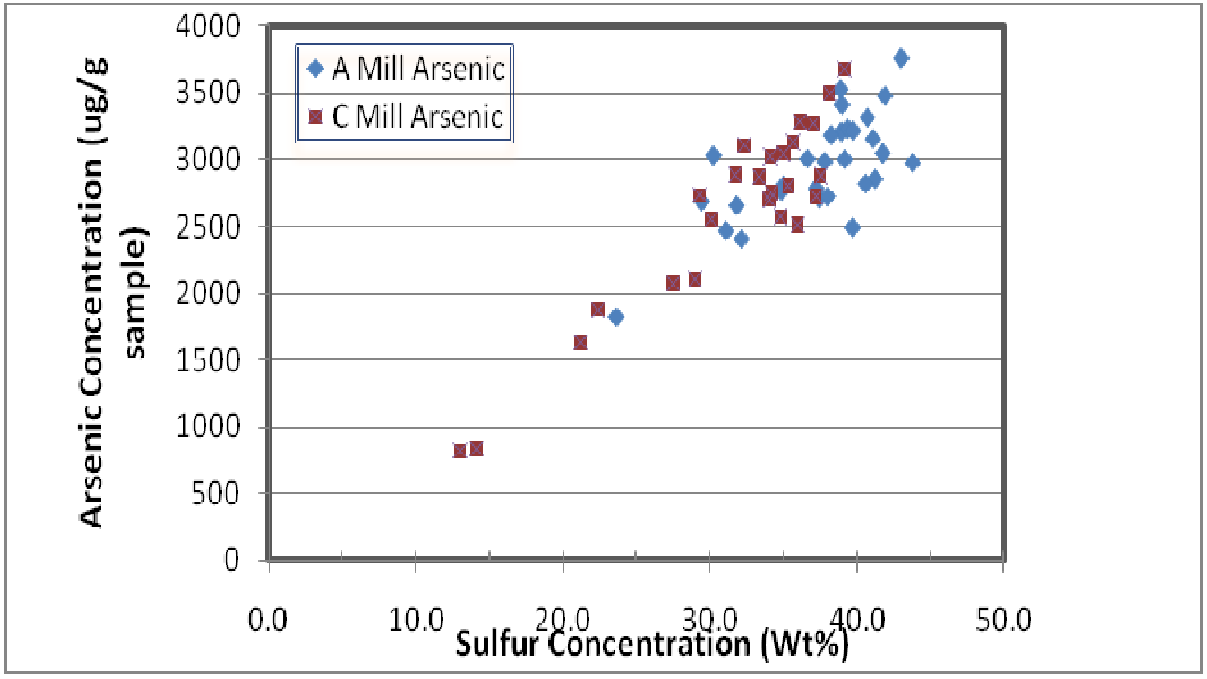
Arsenic, Lead, Antimony and Mercury

Inorganic (inorganic material assay) and pulverized Alabama Raw Coal (typical values) are shown in table

	Inorganic (test) Techinomics' Throat "A" Pulverizer Mill	Raw Alabama Coal	Typical Distribution Inorganic/ Organic- Trace Metal Concentration ratio
Arsenic	2000 PPM	5-20 PPM	200X
Lead	10 PPM	0.1 – 10 PPM	2X
Antimony	10 PPM	0.1 – 1 PPM	20X
Mercury	10 PPM	0.11 – 0.17 PPM	70 X

Arsenic

Table shows a very strong correlation between sulfur and arsenic concentrations in the inorganic material samples. Samples taken from both mills show a very strong correlation between sulfur and arsenic concentrations in the inorganic material samples. The proper operation of the coal mill results in a doubling of the collection rate of inorganic material which results in a two-fold increase in the collection of arsenic. While the ratio of arsenic/sulfur (pyrite) in the inorganic material collected from both mills is the same, the A Mill produced more pyrite than the C Mill and therefore collects more arsenic as well. Removal of inorganic material by correct operation of the mill would result in a removal rate of 3,150 lb/year of arsenic from the boiler coal feed based upon these results.



Lead

Lead concentrations do not correlate linearly with sulfur (pyrite) concentrations. While the A Mill rejects more pyrite than the C Mill, there is not a significant difference in the lead concentration in samples from the two mills. Removal of inorganic material by correct operation of the mill resulted in a removal rate of 17 lb/year of Lead from the boiler coal feed

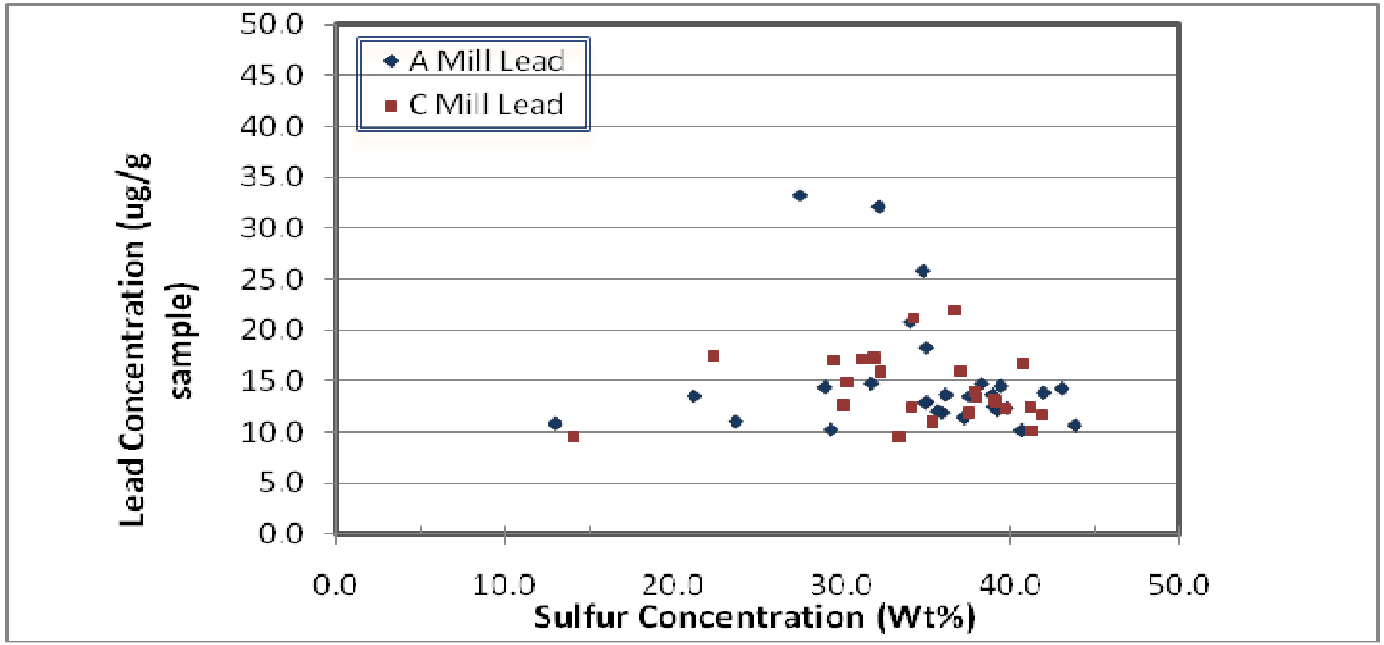


Chart 2 - Correlation between Sulfur (Pyrite) and Lead

Antimony

Antimony exhibits a weaker correlation with sulfur than is observed for arsenic. However, Figure 3 shows that antimony rejection increases as the pyrite rejection increases. While the ratio of antimony/sulfur (pyrite) in the inorganic material produced from both mills is approximately the same, the amount of inorganic material produced by the A Mill is greater than the C Mill and therefore more antimony is collected as well. Removal of inorganic material by correct operation of the mill resulted in a removal rate of 9 lb/year of antimony from the boiler coal feed.

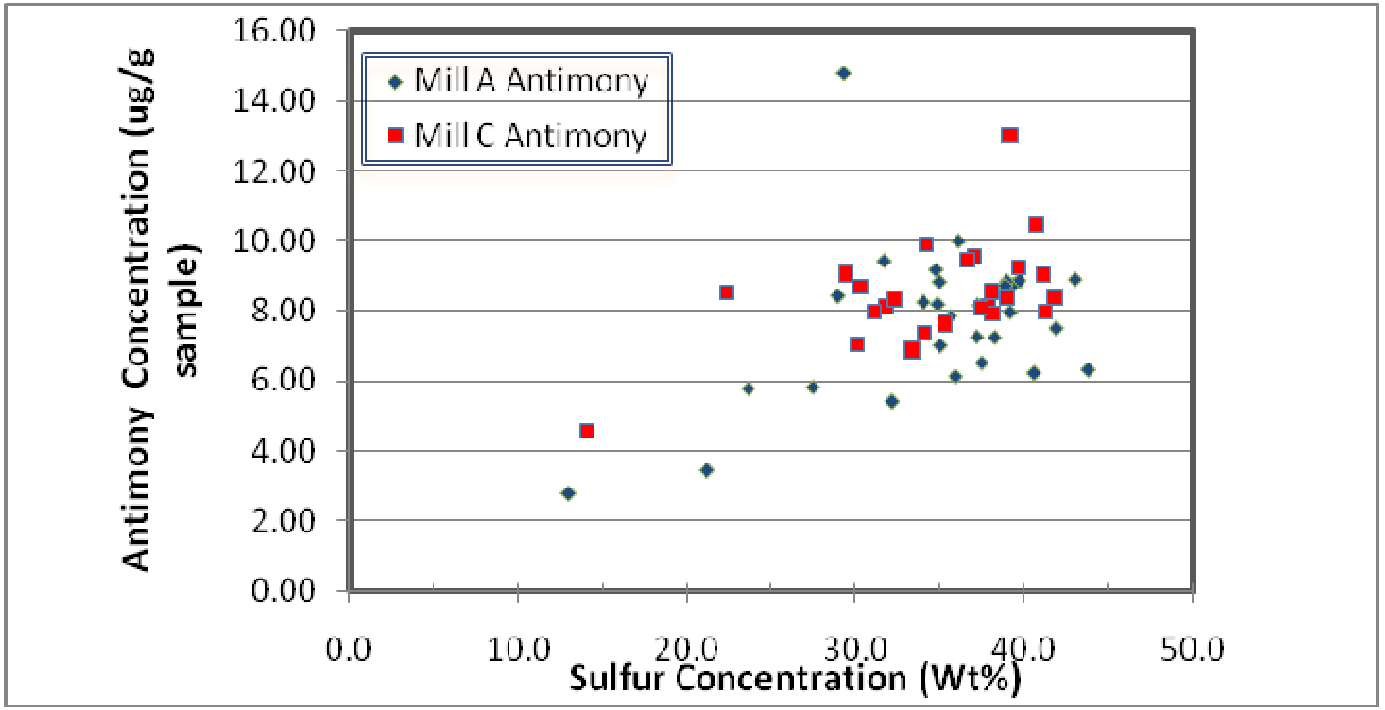


Chart 3 - Correlation between Sulfur (Pyrite) and Antimony

Mercury

Mercury was removed along with the inorganic material from the pulverizer. Although not as strongly correlated as with arsenic, the mercury concentration was positively correlated with the pyrite removed by the mill. The relationship appears to be: the higher the concentration ratio (as seen in Table 1) of the trace metals in the pyritic inorganic material to the raw coal, the stronger the correlation between pyrite removal and the metal removal. Removal of inorganic material by correct operation of the mill would result in a removal rate of 9 lb/year of mercury from the boiler coal feed indicated by these results.

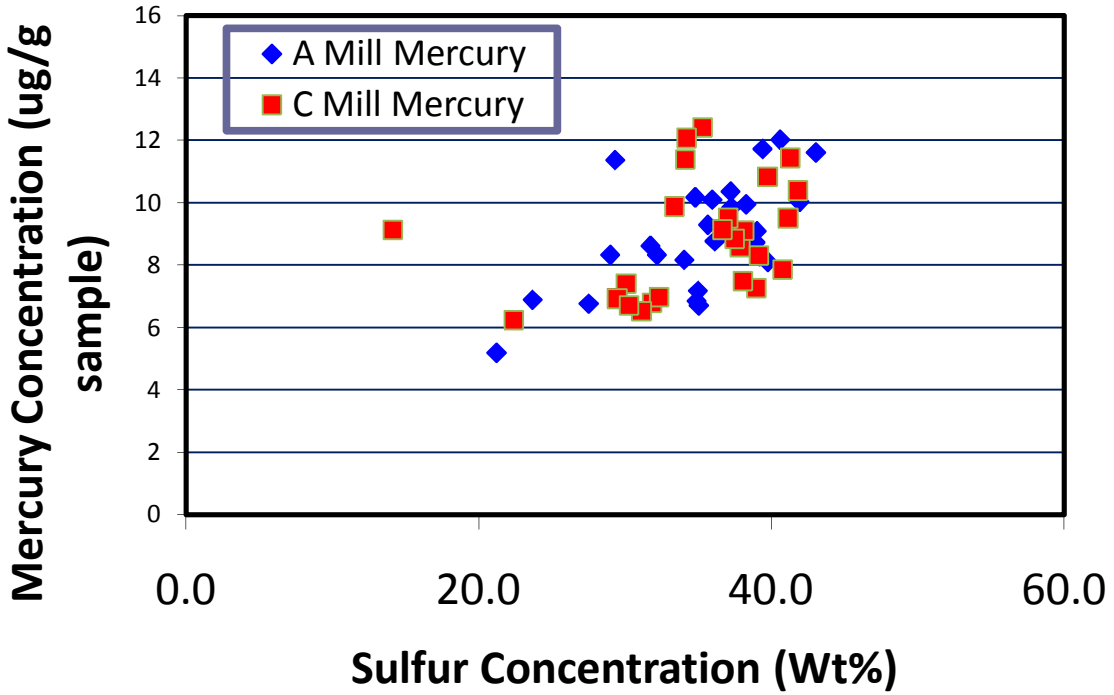


Figure 4 - Correlation between Sulfur (Pyrite) and Mercury

SCR Catalyst Life and Arsenic

Removal of arsenic from the coal before it is burned can extend the life of the SCR catalyst .

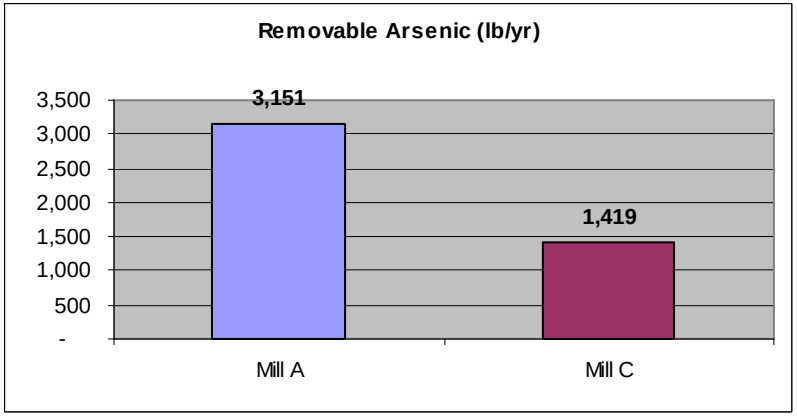
For example a 10% reduction in arsenic can be expected to produce a several thousand hour increase in expected catalyst life.

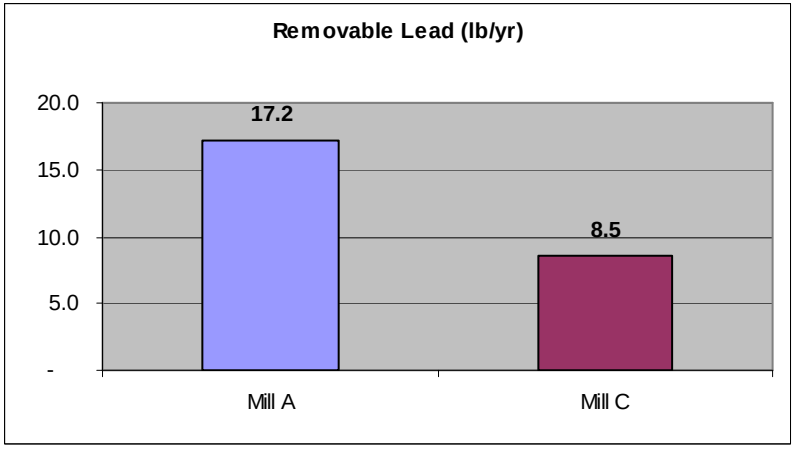
Reduction in arsenic concentration of the coal feed in the Greene County testing could result in a savings on the order of $25-100,000/year.

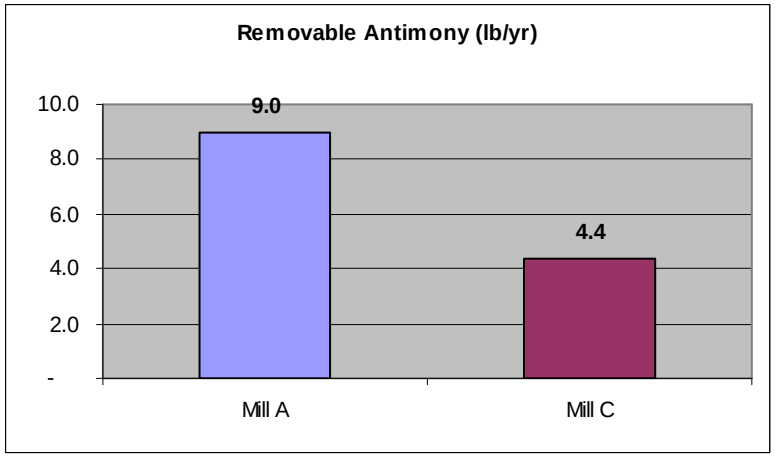
On a nationwide basis, the potential cost savings in SCR catalysts are substantial. Total US SCR catalyst cost is approximately $200-400 million dollars per year.

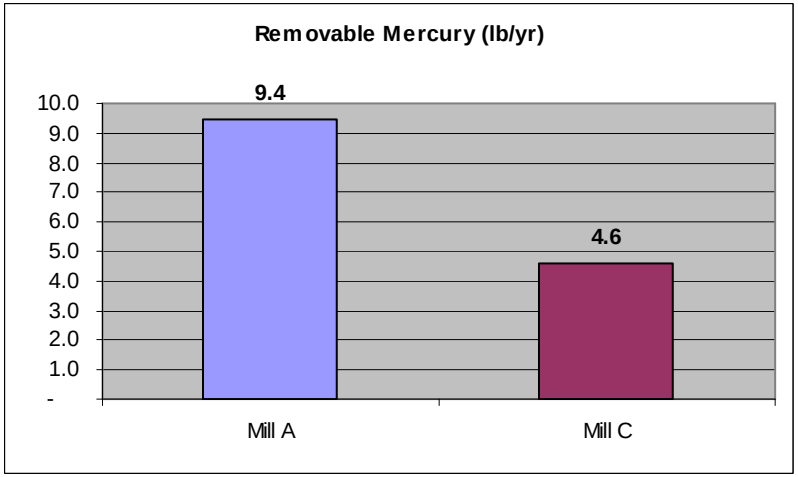
Pulverizer Operation

The operating performance for removal of inorganic material (Trace Metals) for Mill A and Mill C were significantly different. Mill A, containing a Techinomics rotating throat, removed 103% more inorganic material than Mill C, containing an OEM rotating throat. This was achieved with approximately the same amount of coal entrainment in the inorganic material collection box. The significance of this improvement is best explained in terms of the amount of trace inorganic metals that can be removed from the mill on an annual basis. The results for each element are shown in the following graphs






Removable Antimony (lb/yr)
10.0
8.0
6.0
4.0
2.0
-
9.0
4.4
Mill A
Mill C


Removable Mercury (lb/yr)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
-
9.4
4.6
Mill A
Mill C

Sulfur, Coal and Energy Production

Determination of pyrite and coal content in the material from properly operated mills was performed. To obtain the proper collection of inorganic material, plant operators must use an after-market upgrade to the mill. This rotating throat reduces the amount of primary air required to the feeder by 20% and results in significantly lower coal pass through to the inorganic material collection system. Lower primary air requirements result in lower station electrical consumption by the PA fans. Reducing the amount of air required for combustion results in 20% available PA fan capacity for the processing of sticky or wet raw coal. Further, the reduction of primary air through the mill results in a detectable reduction in NOx emissions from the plant effluent stack monitor.

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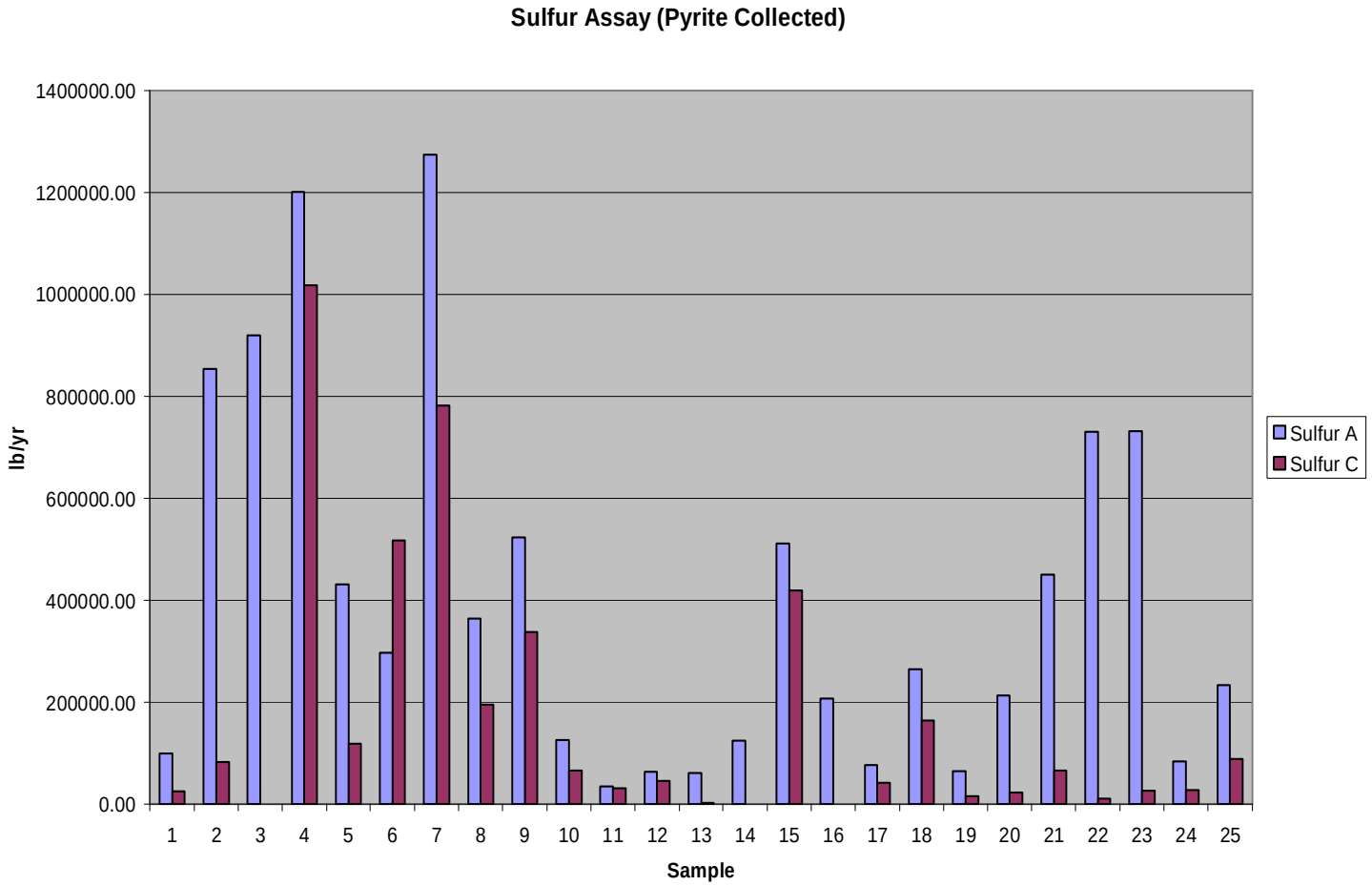

Proper operation of the mills will result in the collection of 570 tons/year of inorganic material, primarily in the form of pyrites.

Since sulfur is 54% of the composition of pyrite, the removal of inorganic material results in a 308 tons/year reduction of sulfur entering the boiler coal feed. At current rates of collection and current prices for SO2 credits, the value of this sulfur is on the order of $ 13,500 per year.

Removal of inorganic material in the mill permits more coal to be fed to the boiler. The value associated with of this larger coal feed in terms of electric generation capacity (MW) is on the order of $5,000-$10,000 per year.

The economic value for air, sulfur, coal and inorganic material removal, taken as a whole, are significant enough, on their own, to warrant more careful operational attention to pulverizers.

Conclusion

We found that arsenic, mercury and other trace metals are effectively removed with more careful operation of coal pulverizers. With minor changes to pulverizer operation, we can reduce the emission of trace metals and gain significant operational benefits.