Title: **High-Carbon Fly-Ash as a Binder for Iron Ore Pellets**

Authors S. K. Kawatra, T. C. Eisele, and S. J. Ripke
skkawatr@mtu.edu
(906) 487-2064
Fax: (906) 487-2934
Department of Metallurgical and Materials Engineering
Michigan Technological University
1400 Townsend Drive
Houghton, MI 49931-1295

Abstract

While many fly-ashes can be used for a variety of applications, there are currently no industrial uses for high-carbon fly-ashes (>6% carbon). These high-carbon ashes are produced by many coal-fired utilites, and represent a major disposal cost. New markets are therefore needed where the carbon content will not be a problem, and may even be of some benefit. One promising application is as a binder for iron ore pellets that are used as blast furnace feed during iron and steel production. The objective of this project is to investigate the use of high-carbon fly-ashes as an iron ore pellet binder. This is the first attempt to identify uses for currently unmarketable, high carbon fly-ash. This is a high volume application; during 1995 iron ore pelletization consumed 637,000 metric tons of binder. The current binder, bentonite clay, is similar in chemical composition to fly-ash.

Currently, bentonite is costly because it must be shipped several hundred miles from the Western United States (i.e., Wyoming) to the iron ore producing region in the Northern Midwest (i.e., Minnesota and Michigan's Upper Peninsula). Fly-ash has the benefit of being produced by power plants located within a few miles of iron ore pelletizing plants. Preliminary work at MTU has shown that fly-ash is a suitable replacement for bentonite in this application and that the carbon content of the fly-ash does not affect pellet quality. In fact, higher carbon content decreases fuel consumption during pellet sintering. This work began when an iron ore pellet producer approached us to study the use of fly-ash as a pellet-binder, which demonstrates an industrial interest for this technology. The primary concern is that pellets produced during preliminary work had barely sufficient dry strengths. Additional work is therefore needed to increase the dry strengths, to assure acceptance of this technology by the iron ore pellet producers. To achieve this goal, hardening accelerators were employed.

Previously, the investigators used fly-ash in combination with calcium hydroxide as binder for iron ore pellets, while calcium chloride was added as a hardening accelerator. However, the addition of chloride salts have a detrimental effect because chlorine can erode the refractory lining of blast furnaces. Therefore, other potential hardening accelerators are being investigated currently.

During production, dried iron-ore pellets are required to have crushing strength of at least 22.3 Newtons (5 pounds force) per 12.7 mm (1/2 inch) diameter pellet. The pellets are then sintered at temperatures up to 1200˚C and must not exhibit a significant degree of spalling or cracking. Pellets are therefore being tested to determine whether acceptable dry crushing strengths and firing characteristics can be achieved.

For this project, a diverse range of marketable and unmarketable fly-ashes is being investigated. Fly-ashes from the E. D. Edwards plant, operated by the Central Illinois Light Company, have been collected, and are being used in the binder studies. These ashes are from three separate coal-fired burners, and vary in their carbon contents as measured by Loss-on-Ignition (LOI) as follows:

- Fly-ash from Unit 1, burning 100% Illinois coal, 1.8% LOI.
- Fly-ash from Unit 2, burning 75% Exxon - 25% Kentucky coal, 6.8% LOI.
- Fly-ash from Unit 3, burning 60% Illinois - 40% Exxon coal, 4.4% LOI.

The Unit 1 fly-ash is a currently marketable ash, while the Unit 2 ash is an unmarketable high-carbon ash and the Unit 3 ash is marginal.

The effects of two hardening accelerators (calcium acetate and calcium nitrate) are under study. These accelerators were selected based on theoretical considerations and on past experience with similar materials in the cement industry, and both have far less corrosive potential than calcium chloride. Representative results from these experiments are shown in Figure 1. It can clearly be seen from these results that both of the accelerators studied are capable of nearly doubling the strengths of the dried pellets for all three the fly-ash types, and that the calcium acetate is more effective than calcium nitrate in this application. It should also be noted that all three fly-ashes produce similar results, regardless of their unburned carbon contents.

Experimentation is currently underway to determine the effects of changing dosage level for these accelerators, and also to evaluate other potential accelerators.

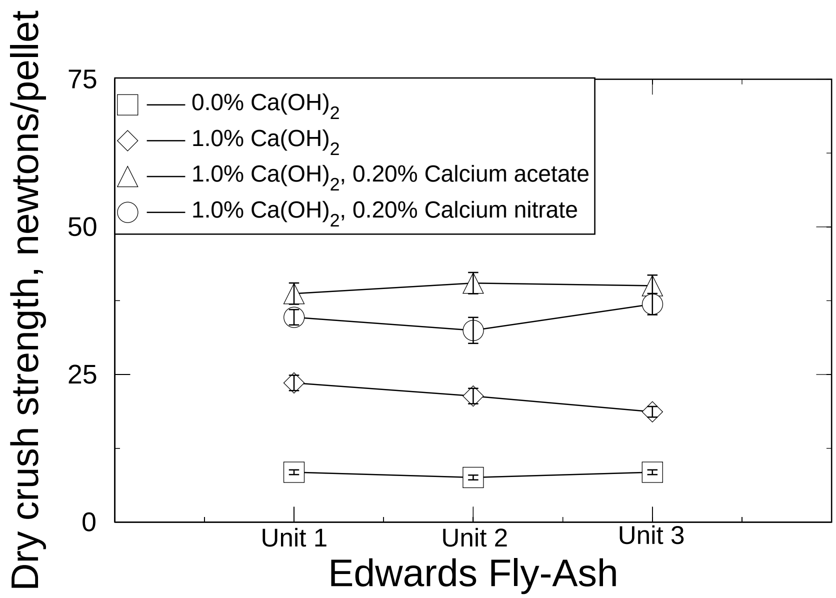

Figure 1. Strength of iron-ore pellets using fly-ash-based binders, at various dosages of calcium hydroxide and accelerators. Pellet strengths are the load in newtons per 12.7 mm (1/2 inch) diameter pellet needed to fracture the pellet. Dosages are expressed as percentages of the total iron ore weight. Fly-ash dosage was held constant at 1.5% of the magnetite weight. Each point is the average over 20 measurements, and the error bars are for the 95% confidence interval. The addition of accelerator, specifically calcium acetate greatly increased the effectiveness of the binding reactions, and makes it possible to exceed the target dry strength of 22.3 newtons (5 pounds force) per pellet with relatively moderate calcium hydroxide dosages.

Published Journal Articles

Journal Articles will be prepared for publication once the current series of experiments are completed.

Completed Presentations

Results of the research will be presented at conferences in the coming year.

Students Receiving Support from the Grant

The following students received support from this grant:

S. Jayson Ripke, Graduate Student, Metallurgical and Materials Engineering

Gabriella Ramirez, Undergraduate Student, Chemical Engineering