Smoldering Combustion for Acid Mine Drainage Remediation

Innovative Applications of Smoldering

Overview

Acid mine drainage (AMD) and acid rock drainage (ARD) present a significant environmental challenge. Both AMD and ARD refer to acidic (low pH) conditions generated through oxidation of metal sulfides (e.g., pyrite) in waste rock or mine tailings after exposure to air and water. The removal of sulfide from mine waste (e.g., tailings) or other ARD-generating waste can prevent the generation of these acidic conditions. Sulfide removal can be achieved through thermal treatment technologies; however, this often requires highly elevated temperatures (e.g., in the range of 600 to 1000°C for removal of sulfide from pyrite). Significant energy input is often required to achieve these elevated temperatures using traditional thermal techniques.

IMAGE 1: STARx Hottpad system for hydrocarbon applications. These modular systems can be scaled to meet throughput requirements for mining applications.

Ex situ smoldering combustion (STARx) is a low cost, energy efficient process initially developed for the treatment of contaminated soils and oil waste sludges. STARx systems have been successfully deployed across the world to treat hydrocarbon contaminated waste materials, where the contaminants provide the fuel that supports the flameless combustion reaction (IMAGE 1). This same high temperature, energy efficient process can also be applied for the treatment AMD/ARD-generating materials. However, as mine waste does not typically contain sufficient organic content to support smoldering combustion in and of themselves, a surrogate fuel is required.

Conclusions and On-Going Development

The STARx technology is a rapid, safe, and energy efficient treatment technology, which has demonstrated potential for remediating AMD/ARD-generating wastes. On-going development work includes:

- Detailed assessment of sulfur reductions as a function of temperature using GAC as a surrogate fuel;
- Evaluation of sulfur reductions for tailing samples from additional sites; and,
- Assessment of the fate of other potentially toxic elements, as well as elements of value.

Technical Approach and Results

Initial proof-of-concept work was completed using vegetable oil as a readily available, non-toxic surrogate fuel capable of smoldering temperatures in the range of 600°C. A series of laboratory column tests were conducted to compare total sulfur content in untreated tailings to tailings after smoldering. Successful smoldering treatment of tailings with a vegetable oil amendment demonstrated a 77% reduction in total sulfur (TABLE 1; IMAGE 2).

TABLE 1: Total Sulfur Content in Untreated and Smoldered Tailings

Sample	Average Total S (mg/kg)
Untreated Tailings	71,600
Smoldered Tailings[1]	16,300
% Reduction	**77%**

Notes: [1] Vegetable oil used as surrogate fuel

IMAGE 2: Untreated tailings sample (left) and smoldered tailings sample after STARx treatment (right)

Follow-on testing was completed to evaluate alternative surrogate fuels. Numerous surrogate fuels are viable; however, smoldering of low concentrations (i.e., 40 to 60 g/kg) of granular activated carbon (GAC) can reliably generate temperatures in excess of 1000°C, which are sufficient for complete (~100%) sulfide removal (IMAGE 3). On-going testing is in progress to evaluate sulfur reductions as a function of temperature in tailings through use of GAC and other fuels at varying concentrations.

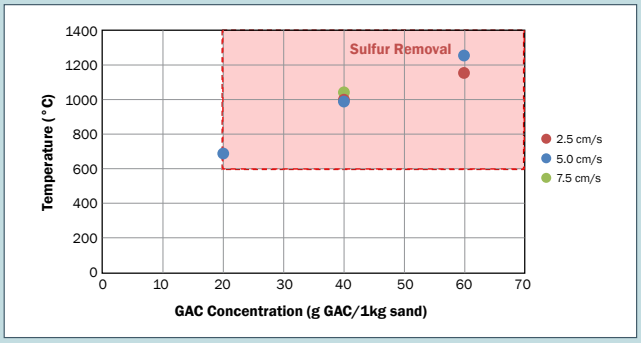

IMAGE 3: Average smoldering peak temperatures as a function of GAC concentration and injected air flux. Removal of sulfide from pyrite typically requires temperatures in excess of 600°C.