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Project Summary

Experimental and Engineering Support for the CAFB Demonstration: Residue Disposal/Utilization

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This work investigated the disposal and utilization of spent sulfur sorbent from the Chemically Active Fluid-Bed (CAFB) process. Lignite ash with a minimum of 10% CaO can be used as a replacement for sand or medium aggregate or as a partial replacement for light aggregate in cement block manufacturing with higher compressive strengths, 14.68 to 26.82 MPa, than standard mixes, 4.62 to 5.62 MPa at 28 day cure tests. This indicates that the cement content of the mix may be reduced when CAFB residue is used. Disposal tests indicate that pH, calcium, and sulfate in the leachate are primary environmental concerns. Some lignites and coal may produce levels of trace materials (e.g., selenium, iron, and manganese) that exceed regulations. Any appreciable sulfide in the spent sorbent must be converted to sulfate before disposal. Fine particle size, possibly as small as -44 μm, appears necessary for complete conversion of the calcium sulfide (CaS) to calcium sulfate ($CaSO_4$) in completely sulfided sorbent. Cementitious compounds may be formed under CAFB operating conditions, thus aiding disposal and reducing leachates from the spent sorbent.

This Project Summary was developed by EPA's Industrial Environmental Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The CAFB (Chemically Active Fluidized-Bed) gasification process was conceived as a means of utilizing high-sulfur residual fuel oil or refinery bottoms as fuel for conventional boilers by converting it to a low-sulfur gas. Subsequent development work and process evaluation revealed that several factors limited its practical application to special situations:

- High-sulfur vacuum bottoms containing high-metal organic complexes and produced from vacuum distillation of atmospheric residual oil, remain the most attractive fuels for the CAFB process.
- The availability of high-sulfur residual oil for CAFB processing is decreasing:
  - Alternative processes are available in the petroleum industry for processing high-sulfur feedstocks.
  - There is a potential demand for these feedstocks as a source of hydrogen for processing heavy crudes or alternative fuel sources such as shale oil or tar sands.
- Retrofit of the CAFB process to gas-/oil-fired boilers appears unlikely in the foreseeable future

because of space requirements and the current natural gas market balance.

- The characteristics of the CAFB fuel gas (low heating value, tar content, particulate content) are not compatible with the needs of many process gas users.

A demonstration plant program sponsored by EPA was initiated with Central Power and Light in 1975 at their San Benito, Texas, plant. The plant had been designed for a residual fuel oil and was adapted to investigate solid fuels, with lignite the fuel of primary interest. In view of the limited potential application with residual fuel oils, the program was also redirected to investigate solid fuels. The objective of the present work was to investigate disposal and utilization of the spent sulfur sorbent. This was an extension of previous laboratory support work, under contract to the EPA, on sulfur removal, solids transport, spent sorbent processing, and the environmental impact of residue disposal.

The current work expanded the data base on CAFB residue disposal/utilization by investigations in four areas:

- Utilization of regenerator residue in cement block
- Processing of regenerator residue for disposal
- Environmental impact of regenerator residue
- Processing of gasifier residue for disposal (sulfide oxidation tests).

The first, if successful, would indicate that the economics of the CAFB process might be enhanced by demonstrating that the residue had commercial value. The next two aimed at demonstrating that the residues had acceptable environmental impact, although processing them prior to disposal might be necessary. The fourth investigation aimed at making an alternative version of the CAFB process available that might be more economical because of the elimination of sulfur recovery facilities.

The San Benito unit experienced many mechanical difficulties and process upsets during the test programs. As a result of these operational difficulties, solid residues representative of steady-state CAFB process operation were not produced. Materials used in the test program included:

- Utilization tests: simulated residue using CaO and Texas lignite ash
- Disposal tests: sulfated bed material from San Benito and Esso units, San Benito boiler fines from the CAFB test, utility lignite ash, and utility bituminous coal ash
- Environmental impact tests: sulfated bed material (lignite fuel), gasifier bed material, regenerator bed material, and RESOX residue (combined lignite and oil fuel test)
- Sulfide oxidation: dolomite 1337

The utilization tests conducted, therefore, were limited to feasibility tests: showing if the residues in an appropriate mix hardened and developed acceptable properties. The disposal tests were, on the one hand, to show that the San Benito materials behave environmentally like the residues from Esso Research Centre, Abingdon, UK (ERCA) and, on the other, to extend the data base on long-term stability of the residues when fixed. Finally, the tests on gasifier residue were basically feasibility tests of a modified CAFB process.

For the residue utilization tests, a simulated regenerator residue was used consisting of a lignite ash doped with calcium oxide (CaO). For the disposal tests and the environmental impact tests, residues from actual operations were available. For the gasifier residue studies, dolomite 1337 was used as the sulfur sorbent.

The important results of the laboratory-scale tests follow.

Utilization Tests

- Lignite ash to which has been added 10 wt % CaO, when used as a replacement for sand or medium aggregate or as a partial replacement for light aggregate in cement block mixes, resulted in higher compressive strengths.
- Use of the CaO/lignite blends may permit reduction of the cement content of the mix.
- Adequate green strength for the substituted mixes appears possible.

Disposal Tests

- Cementitious compounds may be formed under CAFB operating conditions from reactions between calcined limestone and either impurities in the limestone or constituents of fuel ash.
- Grinding CAFB residues and including sand in the mix may be necessary to achieve fixation through cementitious reactions.

Environmental Impact Tests

- Leaching tests on San Benito residues, in general, gave results similar to those from previous work.
- Environmental concerns continue to be the potential levels of pH, calcium, and sulfate in leachates.
- For lignite feed, since ash compositions do vary widely, some trace elements, notably selenium, iron, and manganese, may exceed environmental regulations.

Sulfide Oxidation Tests

- Fine particle size, possibly as small as -44 μm, appears necessary for complete conversion of calcium sulfide (CaS) to calcium sulfate ($CaSO_4$) in dolomite 1337 that is completely sulfided.
- Utilization of limestone or dolomite in desulfurization may be constrained by the ability to convert the sulfide to sulfate for disposal.