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LIME IN ENVIRONMENTAL USES
SOLID WASTE

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Lime has an important role in the safe, efficient handling and disposal of solid wastes.

First, lime, calcium hydroxide is used to fabricate Refuse Derived Fuel pellets made from the organic fraction of municipal waste.

Lime is used in preparing clay liners for landfills so leachate won't contaminate the underlying and adjacent soils and aquifers.

Lime is also used to treat leachate run-off from the landfills, and finally lime is used in stack gas scrubbing for solid waste incinerators, cleaning the gases of toxic and hazardous components such as SO_2 , HCl and heavy metals.

Refuse Derived Fuel Pellets (RDF)[1]

The disposal of refuse is a matter of increasing concern for municipalities and state governments throughout the U.S. In a 1987 report to Congress, the U.S. Environmental Protection Agency (EPA) estimated that the nation generated approximately 185 million tons of municipal solid waste (MSW) in 1990. Further, it was projected that the amount of municipal waste generated by the year 2000 will be 160-290 million tons per year. As existing landfills become filled to capacity and new landfills more costly to site, the development of alternative disposal methods is becoming critical. In addition, the refuse being buried contains considerable quantities of energy that can replace conventional fossil fuels. Some of the main problems of using refuse for fuel have been the poor quality of the fuel, its variability, and its biological and chemical instability.

An improved method for turning refuse into an environmentally safe and economical fuel has recently been developed by researchers from Argonne National Laboratory (ANL). In this method, recyclable metals, glass, and some plastics are separated from the refuse. The remaining (combustible) fraction is combined with an alkaline earth metal hydroxide, in this case a calcium hydroxide binding additive and formed into cylindrical pellets. These pellets are hard and odorless, can be stored for up to three years without significant biological or chemical degradation, and due to their increased bulk density, are more durable and can be more easily transported than other types of waste-derived pellets.

The other, and possibly more important, benefits of the refuse-derived fuel developed by ANL, include significant reductions of sulfur oxides (SO_x), nitrogen oxides (NO_x) and CO_2 in the flue gases, and the trapping of the chlorine combustion products such as HCl that are formed from the remaining plastics in the refuse. This makes the pelletized binder-enhanced RDF (b-dRDF) a part of the environmental solution, rather than a part of the problem.

The feasibility of producing a b-dRDF pellet has been demonstrated in the laboratory and in a large-scale pilot plant test conducted by ANL, and the U.S. Department of the Navy at a Naval Air Station at Jacksonville, Florida. Full-scale commercial fabrication of over 600 tons of b-dRDF pellets was completed at two processing facilities: Reuter Inc. and Future Fuels, Inc. The commercially produced pellets gave very good agreement with the experimental results obtained during the laboratory and pilot-scale tests. Subsequent full-scale combustion tests with co-fired b-dRDF pellets and coal were conducted at ANL in a large 170,000 lb/hr (20 MWe) spreader-stoker utility boiler. These tests verified the predicted reduction of SO_x, NO_x, and CO_2 in the flue gas and the reduction of heavy metals and organics in the ash.

Considerable industrial, state and federal participation was involved in critiquing the full-scale combustion test plan and witnessing of the actual test runs. Subsequent interest in the use of the b-dRDF pellets as an alternative fuel source is indicated by the more than 370 requests for the test reports. A collaborative effort between ANL, the U.S. Department of Energy, the British Department of Energy and Warren Spring Laboratory of the U.K. was initiated to fabricate b-dRDF pellets in England and test the emissions resulting from the combustion of the b-dRDF pellets both in combination with coal or when fired alone.

Firing of b-dRDF pellets with coal in existing coal-fired spreader stoker boilers can be accomplished with little or very minimal physical modifications to be made to the boiler and its ancillary systems. A recent EPRI study indicates that between 1972 and 1984, nine utilities conducted short term co-firing tests of RDF with coal. Results of these tests have indicated that:

- Boilers can be modified at relatively low cost to accommodate co-firing of coal and RDF
- Co-firing of coal and RDF requires relatively minor alterations in the operation of the combustion equipment
- Air pollution control equipment which functions for coal will also function with acceptable efficiencies for co-firing of coal and RDF

ANL has recently conducted pilot-scale tests in which it has been demonstrated that b-dRDF pellets can also be successfully fired with coal in suspension fired boilers by pulverizing both the pellets and coal at the same time in a common pulverizer prior to firing. Alternatively, Reuter has developed a "flake" type of RDF which is typically 3/8 - 1/2" in size and has a bulk density of about one-half that of coal. This "flake" configuration is formed by compressing the basic RDF substrate. This type of RDF should also be suitable for co-firing with coal in suspension-fired boilers.

Densified b-dRDF pellets containing a calcium hydroxide binding agent have demonstrated the following important advantages over conventional dRDF pellets fabricated without a binder additive.

1. Bulk density is a good indicator of the mechanical strength and durability of dRDF pellets. Pellets fabricated with a calcium hydroxide binding agent have consistently demonstrated, both in the laboratory and when fabricated commercially in large quantities (i.e., hundreds of tons per day), bulk densities 75% greater than pellets without a binder. This increase in bulk density allows the pellets to be more easily transported and minimizes handling and conveying problems when firing the pellets.

2. The use of calcium hydroxide as a binding agent allows the pellets to be stored outside for a period of six months without biological and chemical degradation. Conventional dRDF pellets without a binder cannot tolerate outside storage periods of longer than four to five days without suffering substantial chemical and biological degradation.

3. Pellets containing a calcium hydroxide binding agent can be stored inside for indefinite periods without biological and chemical degradation. Such pellets have been stored at ANL for over three years. Pellets without a binder agent show visual biological degradation within two to three weeks.

4. b-dRDF pellets containing a calcium hydroxide binding agent contain 2% fewer 3/8 fines than conventional b-dRDF pellets without a binding agent. This reduction means less bridging and jamming in feed hoppers and conveying systems. Fewer fines also means fewer agglomeration problems when stored in feed hoppers and fewer "dusting" problems when pellets are being transported or conveyed.

5. The optimum moisture content when pellets are fabricated without a binding agent varies between approximately 15 and 20%. For moisture contents greater than 20%, it is not possible to produce even a marginal-quality pellet. With a calcium hydroxide binding agent, quality pellets can be produced with moisture contents up to and including 36%. Because considerable drying of the RDF substrate is necessary to reduce the moisture content to a maximum of 20% for conventional dRDF pellets, a substantial energy savings is realized by producing pellets containing calcium hydroxide.

6. Uncontrolled (prior to pollution control devices) sulfur dioxide (SO_{21}) flue gas emissions decreased from the coal baseline of 1,600 ppmv as blend ratios of dRDF/coal increased, and as the binder percentage was increased.

7. Uncontrolled nitrogen oxides (NO_x) flue gas emissions decreased from the coal base line of 300-350 ppmv as blend ratios of dRDF/coal increased and as binder percentage increased. The data fluctuated; however, general trends were shown.

8. The uncontrolled hydrogen chloride (HCl) flue-gas emissions increased above the coal baseline of 15 ppmv when dRDF/coal blend firing rates were increased. However, the uncontrolled HCl flue-gas emissions were reduced as the amount of lime binder was increased from 0 to 8%. For example, i.e. at a 30% dRDF/coal blend with 8% binder, the HCl emissions were approximately 32 ppmv. With a removal efficiency of 95%, the HCl emitted to the atmosphere was well below the proposed EPA control level of 25 ppmv.

9. The CO_2 emissions were reduced by the addition of a binding additive, the CO_2 emissions were reduced approximately 5% compared to b-dRDF without a binder additive, while an 8% binder resulted in a reduction of approximately 10%.

10. No detectable concentrations of bromides of fluorides were found in the flue-gas emissions at sampling locations 9 or 10. Detection levels were 2.5 ppmv for HF and 2.0 for HBr.

11. The concentration ranges for toxic metals in the flyash and bottom ash were significantly lower (and in some cases orders of magnitude lower) than levels typically found in mass burn facilities.

12. All total tetra through octa chlorinated dioxins and furans were below the detection levels for all flue-gas samples taken at the stack.

13. A definite decrease in PAH and PCB emissions was observed with increasing binder content in the pellets.

14. All flyash samples tested were below the detection levels for total tetra through octa chlorinated dioxins and furans.

15. Bottom ash and flyash samples from all test runs passed the EP Toxicity tests. A total of 103 flyash samples and 113 bottom ash samples were analyzed. It is important to note that lead and cadmium, which have been found to fail the EP tests in many cases involving the mass burning of municipal solid waste, were not found to exceed the limits of 5 and 1 mg/L, respectively, in the leaching solution.

16. The test results show that b-dRDF pellets can be fed along with coal to an existing stoker-fired boiler at rates up to 50% dRDF (by heat input) without upsetting combustion stability or the ability of the boiler to maintain load demand. Modifications to the system could permit firing at dRDF rates in excess of 50%. According to our studies, firing rates in excess of 50% should present no boiler operational problems if relatively minor modifications are made to the boiler (e.g., feed and ash handling system capability increased). Fuel handling, slagging, and clinkering problems were not noticeably worse than when firing only coal.

17. Visually, the carry-over of particulate matter from the furnace into the convection bank of the boiler did not appear to be significantly greater than when firing coal alone. "Sparklers" were rarely evident. When dRDF fuel was bunkered with coal, the refuse material could be handled without incurring housekeeping problems in the boiler plant. Some minor odors were reported by the operating personnel.

Landfills[2]

In constructing landfills, much care must be taken to assure that the landfill is situated in a geologically stable area, free from fault zones, above the ground water level and a liner system is built so that leachate will not be released from the contaminant zone without treatment. Methane gas must also be controlled and collected.

Lime is used to construct these impermeable layers by mixing it with clay soils and forming pozzolonic materials that have decreased permeability, in the order of 10^{-7}. In the U.S. the solid waste disposal laws require all landfills to be constructed with impermeable liner systems and leachate collection and treatment systems, and methane control systems.

Of course, there are many older landfills that do not meet these requirements, and over time must be remediated. It appears some of these landfills will have to be excavated and rebuilt, and some merely capped with an impermeable clay layer. Here again lime is used to make the clay stable.

In areas where cities or new roadways need to be constructed over an existing or closed landfill, lime slurry injection has been utilized to stabilize the fill and supply sufficient bearing capacity. Generally lime/fly ash slurries are injected to refusal, forming a light-weight cement matrix of the compacted trash. The high pH imparted by this lime mixture also stops methane production.

Incineration Scrubbing

When solid waste is incinerated in mass burn facilities, it is necessary to lime scrub the stack gasses to control SO_2 , HCl, and heavy metals. Lime spray drying is very effective in this application. Lime reacts with the SO_2 to form gypsum, and reacts with HCl to form Calcium Chloride. This is important because it removes the chlorine from the system, preventing the formation of Dioxins.[3]

Ash Stabilization - Fixation and Utilization

The ash remaining from the combustion of the solid waste must also be treated with lime to chemically fix the heavy metals and make them non-leaching.

This treated ash can be then utilized in building construction as engineered fill or as raw material for lightweight aggregate or building blocks.

Summary

As you see, lime has many beneficial uses - uses which we only begin to appreciate as new developments occur.

References

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3. Role of Combustion and Sorbent Parameters in Prevention of Polychlorinated Dibenzo-p-dioxin and Polychlorinated Dibenzofuran Formation during Waste Combustion; Brian K. Gullett, et. al. , U.S. EPA Research Triangle Park, N. C. 27711, 1994.