Recent Innovations in Controlling Dust Emissions in the Bauxite/Alumina Industry

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Abstract

Fugitive dust emissions are becoming a growing global concern. In the bauxite/alumina industry, dust emissions are generated during the mining, transport and handling of bauxite, and from operations in red mud disposal areas. While environmental, health and safety issues are the primary reasons for concern; dust can also have a major economic impact as the result of increased maintenance and clean-up costs, and the loss of bauxite prior to digestion. Although water can minimize certain dust problems, the benefits are short term, and the addition of water can cause wet bauxite handling problems and increased transportation costs.

This paper summarizes recent innovations for reducing dust emissions in a range of operations from bauxite mines to red mud disposal areas. The examples provided include a method for controlling dust during mining operations; automated equipment and chemicals for controlling bauxite dust; road and surface stabilization; and red mud disposal area dust control.

Introduction

Dust control is a concern in most mining and mineral processing operations. Environmental regulations, community relations and worker health and safety issues often dictate the level of dust control required. However, dust emissions can also have a significant impact on operating and production costs.

This paper will review current industry best practices for dust control, and provide information regarding new dust control technologies developed for the bauxite/alumina industry.

Mechanical dust suppression

Mechanical dust collectors, such as cyclones, wet scrubbers and fabric filters (bag houses) are designed to remove and collect dust from enclosed areas, such as belt-to-belt transfer points.

Some advantages of mechanical dust suppression are:

- If designed, installed and operated properly, mechanical dust collectors effectively prevent dusting at point source locations
- Except for scrubbers, no moisture or chemicals are added to the process

Disadvantages include:

- High initial capital cost
- High operating and maintenance costs, e.g., energy, bag replacement, corrosion and deposition Mechanical collectors can only be used for point source emissions

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- Collected dust is typically discharged to belts, causing problems at the next transfer point or during stacking operations

Wet dust suppression using water

Water is commonly used to control dusting on roads, and in crushing, handling and storage/reclaim operations. Assuming the substrate is easily wetted by water, and the water is effectively applied, the wetted material will have a lower propensity for generating dust.

Some advantages of using water are:

- Water is usually inexpensive and easily obtained
- Except for water trucks and fog systems, feed equipment is relatively inexpensive to install and operate
- Water provides good short-term dust suppression, assuming the dust particles are contacted and wetted.

Disadvantages include:

- Dust control is short-term; water needs to be applied often
- Water has a relatively high surface tension resulting in large liquid droplets and inefficient particle knock-down and distribution
- Water does not easily wet many substrates, resulting in inefficient dust control
- Inefficient use of water results in material handling problems, e.g., freezing, belt carry-back, chute pluggage and inefficient crushing and screening operations
- In the Bayer Process, excess and variable moisture levels in bauxite ore affects digester chemistry and water balance

Chemical dust suppression

Chemical dust suppressants enhance the ability of water to provide the desired dust control effects with the least amount of moisture. While the use of chemicals appears to add to the cost of controlling dust, careful analysis shows that the benefits of chemical dust suppressants typically reduce overall dust suppression costs when compared to mechanical collectors and/or water alone.

To help explain these benefits, a description of the chemical dust suppressants used in the bauxite/alumina industry is required.

Wetting agents

Wetting agents are surfactant formulations that improve the ability of water to wet and agglomerate fine particles. Available products range from single component, commodity surfactants to specialty chemical formulations that contain blends of surfactants with organic and inorganic additives. Binding agents may also be included for long-term (residual) dust control effects.

The primary mechanisms for wet dust suppression are particle capture, bulk agglomeration and surface stabilization. In particle capture, suspended dust particles are contacted, wetted and captured by liquid droplets. An example of particle capture is a spray curtain at a truck or rail car unloading station, where liquid droplets knock down fugitive dust during unloading. In bulk agglomeration, a liquid is sprayed on a bulk quantity of a material in an area of mixing to wet and agglomerate fine particles. Spraying a liquid in a screw conveyor to reduce the dustiness of a bulk solid is an example of bulk agglomeration. In surface stabilization, a liquid is sprayed on material surfaces, such as roads and storage piles, to prevent wind and mechanical dust generation.

The wetting of bulk solids for dust control involves both spread and capillary wetting phenomena. Spread wetting is the ability of a liquid to spread over and wet a solid surface. Capillary wetting is the ability of a liquid to penetrate porous solids, such as a mass of fine particles.

Although surfactants can increase or decrease spread and capillary wetting, wetting agents designed for dust control generally improve both wetting actions. Improved spread wetting has a positive effect on all dust control applications. Capillary wetting can have a positive or negative effect depending on the substrate and dust control mechanism involved.

Capillary wetting has no influence on the particle capture mechanism, whereas it has a significant effect on surface stabilization, e.g., liquid penetration into a packed roadbed. For bulk agglomeration, capillary wetting can increase liquid penetration into masses of fine particles, resulting in improved liquid distribution. However, it can also increase liquid penetration into the pores of larger particles, decreasing the amount of surface film available for inter-particle binding. Therefore, different wetting

agent chemistries and concentrations are needed to achieve the optimum balance of spread and capillary wetting for each application.

Binding/agglomerating agents

Binding agents provide long-term (or residual) dust control compared to water (wet suppression or foam). Water-based products are applied as liquid sprays or foams. Therefore, all of the criteria described previously also pertain to binding agents. Moreover, all of the complexities and uncertainties are magnified by the addition of a new parameter: dust suppression as a function of time.

Generally speaking, binding agents are classified as humectant and adhesive formulations. Humectants, such as magnesium and calcium chloride, absorb and maintain surface moisture to keep the dust "wet." Adhesives effectively maintain fine particle agglomerates in the absence of surface moisture. Oils and polymers are considered adhesives for dust control applications. Binding agent performance is related to the physical and chemical properties of the substrate, the application technique (liquid spray or foam), and the treated materials' storage and handling conditions. For example, a humectant binder will be effective if the material being treated is cool, easily wet by water, and stored in a cool, humid environment. The same treatment will be ineffective if applied to a hot substrate and/or subjected to hot, dry storage conditions.

Binding agents are used when it is either impractical or uneconomical to control dust using water-based technologies (wet suppression or foam). Typical binder applications include bulk treatment at a mine to reduce dusting during transport and unloading; bulk treatment at an end-user's site prior to active storage; and surface stabilization for roads, tailings basins and inactive storage piles.

Recent innovations for the bauxite/alumina industry

A number of new technologies have been developed, or are under development, for controlling dust in the bauxite/alumina industry. The primary objectives in developing these technologies were to:

- Control dust where no methods are currently available
- Control dust using significantly less water compared to current chemical dust suppressants
- Develop automation to further reduce water usage, while also reducing chemical costs
- Identify more environmentally friendly chemicals compared to current dust suppressants
- Develop products with no oils or other organic compounds that would interfere with the Bayer Process

A summary of each new technology follows.

Controlling dust during bauxite mining operations

There currently are no mechanical or chemical technologies for reducing dust emissions during open pit mining operations. Therefore, several methods for controlling dust (and gaseous emissions) during blasting and mining operations are being investigated. While still in the developmental stage, preliminary data suggest that dust emissions during blasting and loading can be reduced significantly. Testing for reducing gaseous emissions, e.g., NO_X, is underway.

Field data from a dust suppression trial at an open pit mining haul truck loading operation are shown in Figures 1 and 2. In Figure 1, dust monitoring data obtained from a real-time aerosol monitor located on a front-end loader shows the reduction in ambient dust levels while loading a haul truck. As shown, dust levels are significantly reduced using a chemical dust suppression method compared to no treatment.

Figure 2 shows mine production data, i.e., the time required to load haul trucks. The data clearly show the production benefit of loading haul trucks in a relatively dust-free environment.

In addition to the positive economic impact, the data suggest that worker health and safety are improved due to reduced dust emissions in the open pit work environment.

Data on dust and NO_X reduction during blasting will be reported at a later date.

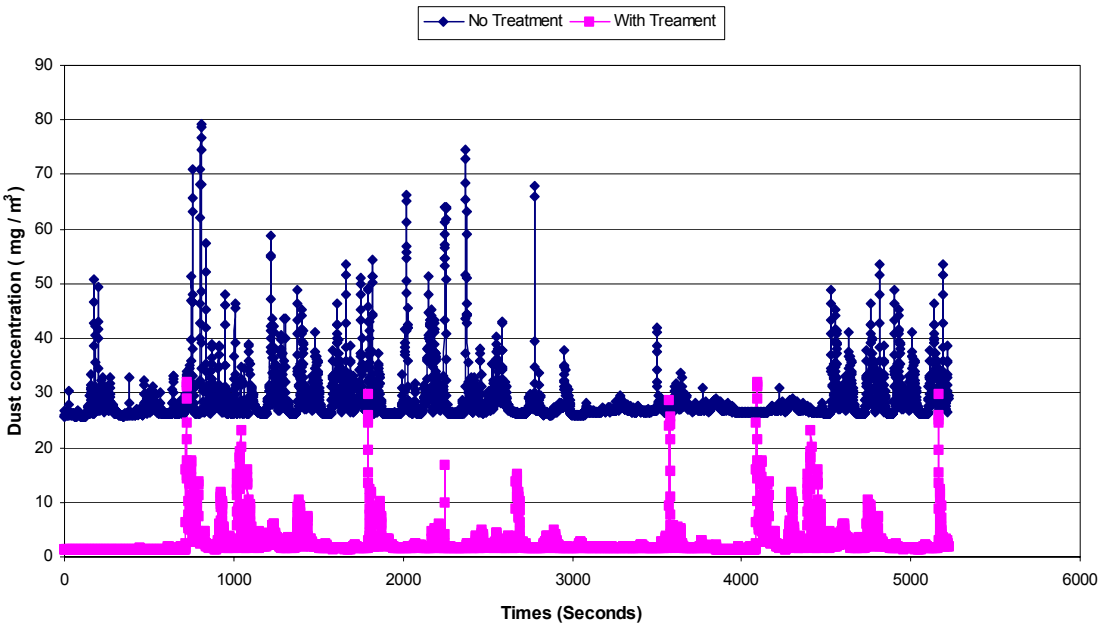

Figure 1: Ambient Dust Levels During Haul Truck Loading

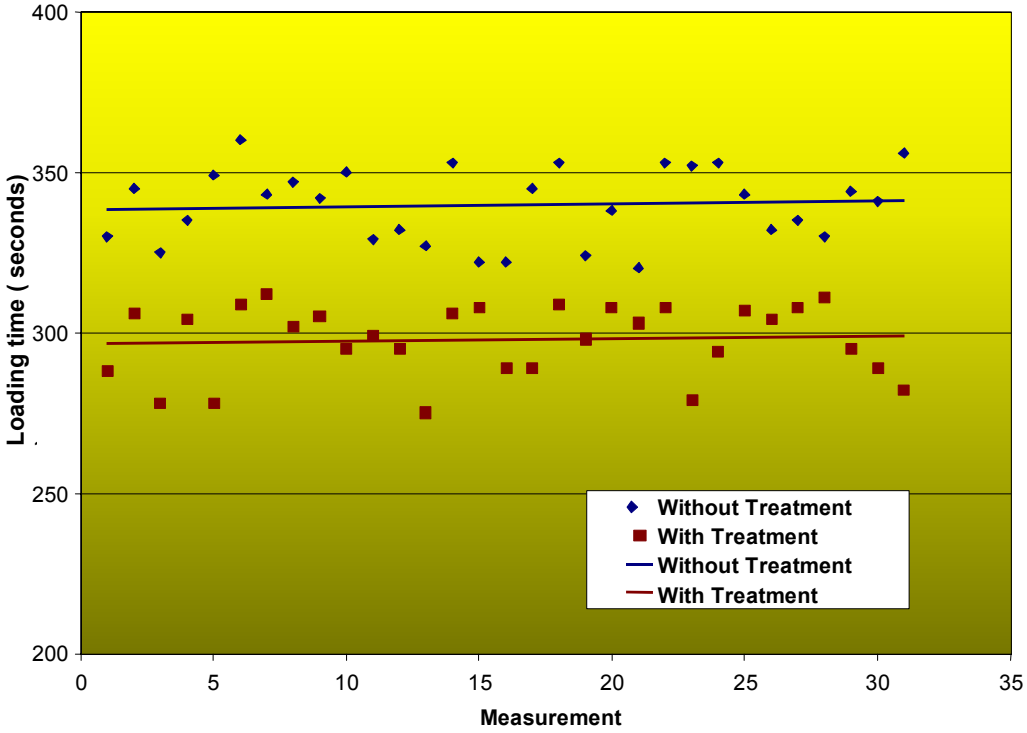

Figure 2: Haul Truck Loading Times in Seconds

Haul road and surface stabilization

A number of commercial road dust and surface stabilization chemicals are available. Road dust chemicals are typically wetting and/or binding agents that minimize dusting and reduce the need for watering. Common chemistries include:

- Chloride salts: act as humectants to maintain moisture in roadbeds. They are relatively inexpensive, but chloride corrosion of vehicles and the environmental impact of chloride run-off are a concern.
- Lignosulfonates: act as humectants and binders. They are also relatively inexpensive, but do not work well in hot, arid environments.
- Petroleum-based: act as binders. They are moderately priced, and effective under most conditions. However, they are not considered environmentally friendly as they are typically waste oils or asphalt emulsions, or based on other residual petroleum products.
- Surfactants: act as wetting agents to improve penetration of water in roadbeds. They are very inexpensive, but only decrease the amount of watering by about 10% to 50%.

New products based on the above chemistries have been developed, or are in development, to obtain the same or better benefits without the negative characteristics, with the primary goal of improving the environmental impact.

To reduce both chemical cost and watering frequency, a road dust monitoring system has been designed to predict the time and location where water trucks are needed prior to a dusting incident.

Details of the above are beyond the scope of this paper, and will be presented as a separate paper at a future date.

Automated equipment and chemicals for controlling dust

Current bauxite dust suppression is accomplished using mechanical dust collectors, water sprays, or traditional chemical wetting and binding agents. The disadvantages of using mechanical and water methods were summarized previously. Traditional wetting and binding agents were not designed for treating bauxite, or did not meet the criteria of reducing the amount of water required and/or having minimal impact on the Bayer Process.

Laboratory studies were conducted to identify a chemical treatment with the following characteristics:

- Environmentally friendly
- Low treatment cost compared to current technologies
- Low moisture addition, i.e., optimum spread and capillary wetting characteristics
- No oils or other components that could negatively impact the Bayer Process
- Long-term, or residual dust control to eliminate the need for additional treatment

After extensive laboratory testing, a product that met the above criteria was developed. Figure 3 shows the relative dust control performance of traditional dust control treatments compared to the new treatment labeled as "Developmental Product." Testing was conducted using a laboratory dust chamber on a Jamaican bauxite ore. Dust measurements were made after drying the treated ore samples in an oven for 48 hours at 221°F (105 °C).

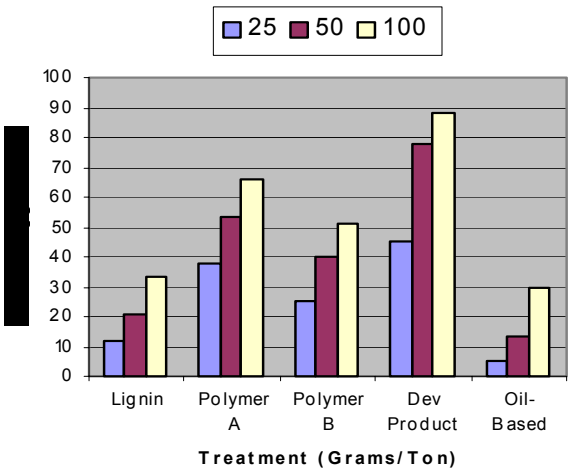

Figure 3: Relative Dust Control Performance

Field-testing at an alumina refinery correlated well with the laboratory findings. Data gathered over the past year show:

- Chemical treatment costs have been significantly reduced compared to a previous treatment

- Water addition has been reduced by 60% to 70%
- There have been no reported dust violations (>10% visual opacity)
- The residual dust control effects last from ship unloading to the digester
- There have been no negative effects on the Bayer Process

In addition to the above, automated feed equipment has been designed to maintain dust control using the minimum amount of water and chemical. Plant test results will be reported when the equipment has been installed and optimized. The equipment design parameters are:

- Used in combination with chemical dust control technologies to maintain dust control performance with lowest possible surface moisture
- Reduces chemical consumption (and costs) by feeding chemicals only as needed to achieve desired results
- Maintains critical surface moisture (CSM), i.e., the surface moisture required to obtain a dust-free material
- Maintains consistent surface moisture for optimum agglomeration and consistent, and predictable moisture balance in the Bayer Process

Red mud disposal area dust control

Red mud disposal areas often create significant fugitive dust problems in hot, dry, windy environments. Due to high pH, and caustic migration to the surface, traditional binders used for typical mining tailings basins are not capable of addressing the red mud dust problem.

Field-testing of standard and developmental binders was conducted at an alumina refinery using small plots to test various products and addition rates under similar environmental conditions. Preliminary results were very encouraging in that a unique polymer formulation was capable of maintaining a stable, dust-free surface under hot, dry conditions. Also encouraging was the fact that the application technique appears to be technically feasible and the treatment costs commercially viable.

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