BENEFITS OF CHEMICAL DUST CONTROL TECHNOLOGIES ON THE ECONOMICS OF COPPER LEACHING OPERATIONS

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ABSTRACT

Mining, crushing and conveying of mineral ores is an integral part of copper leaching operations. An important issue for the copper mining industry is the control of fugitive dust emissions. A variety of dust control technologies have been developed to help mining operations meet permitting requirements and environmental compliance for fugitive dust emissions.

This paper reviews traditional dust control technologies and new technologies developed by BetzDearborn that are designed to provide effective dust control while increasing the profitability of mining operations.

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:

- Effectively prevent dusting at point source locations
- No moisture or chemicals are added to the process (except for scrubbers)

Disadvantages include:

- High initial capital cost
- High operating and maintenance costs, such as energy, bag replacement, corrosion, deposition and heating of make-up air
- Can only be used for point source emissions
- Collected dust is typically discharged to belts causing problems at the next transfer point, stacking operations, etc.

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 and the water is effectively applied, the wetted material will have a lower propensity for generating dust.

Advantages of water include:

- Easily obtained and inexpensive
- Feed equipment is relatively inexpensive to install and operate (except for water trucks and fog systems)
- Good short-term dust suppression, assuming the dust particles are contacted and wetted

Disadvantages of water include:

- Dust control is short-term; water needs to be applied often
- Relatively high surface tension results in large droplets and inefficient particle knock-down and distribution
- Does not easily wet many substrates, resulting in inefficient dust control
- Inefficient use results in material handling problems, such as freezing, belt carry-back, chute pluggage, spillage, and inefficient crushing and screening operations
- Excess and variable moisture levels in ore can lead to water balance problems in copper leach circuits

CHEMICAL DUST SUPPRESSION

Chemical dust suppressants help provide the desired level of dust control with a minimum amount of moisture. While using chemicals appears to add to the cost of dust control, careful analysis shows that the benefits of chemical dust suppressants typically reduce dust suppression costs compared to mechanical collectors and/or water alone. To better clarify these benefits, it is important to understand each type of chemical dust suppression technology.

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 the bulk 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 the surface of a material, 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, but it has a significant effect on surface stabilization, such as 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 interparticle binding. Therefore, different wetting agent chemistries and concentrations are needed to achieve the optimum balance of spread and capillary wetting for each application.

Foaming Agents

Foaming agents are used to convert water and air into foam. Dust control foam is a dry, stable, small-bubbled foam with a consistency similar to shaving cream. Foaming agents are primarily high foaming surfactants, and may also contain wetting and binding agents.

Dust control foam functions similarly to liquid spray wet suppression, in that the foamed liquid wets and agglomerates fine particles. The advantages of foam over liquid sprays are improved liquid distribution, resulting in lower liquid feed rates; and improved fine particle capture, which reduces breathable dust. Improved liquid distribution is realized by the large increase in liquid surface area. About 1 gal. of liquid spray/ton (4.2 L/tonne) of material is converted to 40 gal. of foam/ton (168 L/tonne). The improved fine particle capture is believed to be due to the foam's ability to engulf and wet fine particles, and/or the "shrapnel" effect, where fragments of bursting bubble films contact, wet and agglomerate fine dust particles.

Because foam dust control mechanisms involve the contact of foam with dust particles, foam is used primarily for bulk agglomeration applications. The most common feed locations are material transfer points and crushing operations. The use of foam in crushers is gaining acceptance as a way of reducing dust with minimal added moisture, while maintaining optimum crusher and screening performance.

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 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 material's 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.

Crusting Agents

Crusting agents are binding agents used for long-term surface stabilization. The chemistry of crusting agents is similar to latex paint. The primary active components are water-based latex polymers that cure to form a mechanically stable water-insoluble film. Wetting and/or viscosity modifiers may be added to affect the rate and degree of liquid penetration into the bulk solid surface.

Surface film (or crust) properties will vary depending on product formulation, solution concentration, solution feed rate and application technique. The properties important for pile crusting are compressive and/or tensile strength, elasticity (flexural strength) and weather resistance (rain, freezing/thawing and ultraviolet light).

The optimum properties for a given application will vary, but elastic properties are usually the most important for maintaining a continuous crust during pile subsidence, expansion and contraction, and light loads. Weather resistance, the ability to maintain a coherent, waterproof film when exposed to the environment, is of equal importance in that elastic properties must be maintained over a long period of time.

Field application techniques are similar to spray painting an irregular surface with exterior latex paint. A primer or seal coat and 1 to 2 finish coats of crusting agent should be applied for complete coverage. Allow time to dry (cure) between coats and treat 24 to 48 hours prior to forecasted rain.

RECENT INNOVATIONS FOR COPPER LEACHING OPERATIONS

New technologies improve the economics of copper leaching operations. These innovations include leach enhancers, which are wetting agents designed to increase copper dissolution, and agglomerating agents, which are polymeric binders for increasing agglomerate quality. The combined benefits are improved leach kinetics and higher copper recoveries due to:

- Improved distribution of leaching solution due to improved wetting, more uniform agglomerates and reduced blinding due to fines migration
- Improved drainage with less solution hold-up, due to reduced surface tension, more uniform agglomerates and reduced blinding due to fines migration
- Reduced PLS turbidity and less crud formation in SX plants
- Improved dissolution of copper due to spread and capillary wetting phenomenon
- No negative impact on SX/EW operations

Because leach enhancer and agglomerating agent technologies are based on the same wetting and adhesion phenomena discussed earlier, BetzDearborn has developed new dust suppression chemicals that combine the benefits of improved dust control, low moisture addition, improved leaching properties and increased copper recoveries. When combined with BetzDearborn's patented automated feed equipment, these chemistries also provide optimum agglomeration and improved water balance. Benefits of the new dust control technologies are summarized below.

Wetting Agents

- New chemistries based on combined research in dust control wetting agents and copper leach enhancers
- Same advantages as standard dust control wetting agents
- No negative effects on leaching or SX/EW
- Positive effects on enhancing copper recoveries, improved percolation and drainage, and reduced solution hold-up

Foaming Agents

- Same advantages as standard dust control foaming agents
- No negative effects on leaching or SX/EW

Binding/Agglomerating Agents

- New chemistries based on combined research in dust control binding agents and copper agglomerating agents
- Same advantages as standard dust control binding agents
- negative effects on leaching or SX/EW
- Positive effects on agglomerate strength
- Improved leaching, percolation and drainage
- Reduced fines migration, PLS turbidity and crud formation

Automated Feed Equipment

- Monitors and maintains constant surface moisture of ore
- Used with chemical dust control technologies to maintain performance with lowest possible surface moisture
- Reduces chemical consumption and costs by feeding chemicals only as needed
- Maintains the critical surface moisture level required to obtain a dust-free material
- Maintains consistent surface moisture for optimum agglomeration and predictable moisture balance in the heap

CONCLUSION

In summary, chemical dust suppressants and automated feed equipment have a number of benefits. First, these technologies eliminate the capital, operation and maintenance costs associated with mechanical dust collectors. They also achieve better dust control, so that the dust normally lost to the environment (which typically assays high in copper) reports to the heap where the copper can be recovered. Copper recovery is also increased due to improved wetting of mineral surfaces, and to improved agglomeration, percolation and drainage, i.e., better distribution of leaching solution and less solution hold-up. These technologies also reduce PLS turbidity and crud formation, and improve water balance by significantly reducing surface moisture and maintaining a constant moisture content in the ore prior to agglomeration/heap leaching.

Together, these benefits can help copper leaching operations increase profitability, while improving environmental compliance.

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