Overview of deposit control

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Effective deposit control in a paper-mill system requires a thorough understanding of the system and analysis of all components of a deposit. Continuous treatment while the system is running and scheduled downtime cleaning are crucial.

Paper-mill deposits may be classified as either inorganic, organic, or biological in nature. Generally, elements of all three can be found. When seeking an effective means of controlling deposits, it is important to analyze and implement treatments that will be effective on all major components.

Inorganic deposits

Examples of common inorganic deposits found in the paper mill system include:

- Calcium carbonate
- Calcium sulfate
- Calcium silicate
- Barium sulfate
- Aluminum hydroxide
- Talc
- Titanium dioxide
- Clay.

Sources of inorganic deposits (also referred to as scale) include both virgin and secondary fiber, carryover of chemical pulping liquor from the pulp mill, fresh water, and white water. Additionally, process additives such as alum, clay, titanium dioxide, talc, and calcium carbonate have scale-forming potential. These deposits tend to build on screens, system piping, pump manifolds, and stock storage chests. They also can be found on paper machine forming fabrics, forming elements, wet press felts, and press rolls.

If left untreated, inorganic scales can restrict pipe flow, scale-over pump manifolds, blind screens, and inhibit drainage and water transfer on the forming table and in the press section (**Fig. 1**).

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Control of inorganic deposits

Common methods used for continuous treatment of inorganic scales include dispersion, crystal modification, and sequestration.

Dispersion

Dispersion is considered to be more of a physical than chemical reaction. Because many inorganic deposit constituents carry a net negative charge, low-molecular-weight anionic polymeric electrolytes such as polyacrylates are commonly used as dispersants in the paper industry. Natural dispersants such as lignosulfonates also are used. These compounds work via a mechanism of charge repulsion. The objective of dispersant treatment is to prevent inorganic particles from agglomerating and forming deposits by maintaining these particles in a colloidal state.

Crystal modification

Inorganic scales which are crystalline in nature, such as barium sulfate, calcium carbonate, and calcium sulfate, are effectively controlled by introducing an impurity into the tightly bound crystal lattice structure of the ion. The impurity distorts symmetrical crystal formation, preventing further growth and deposition. Commonly, phosphonates and polyacrylates are used for this purpose.

Sequestration

Sequestrants, which include chelants and threshold inhibitors, are used to maintain metal cations such as calcium, barium, copper, iron, and manganese in solution, preventing them from combining with anions present in the system and forming deposits.

Chelants function by forming a ring structure around the offending cation and incorporating it into the inner ring. Common chelants include EDTA, NTA, and DTPA.

While chelants react with metal ions in stoichiometric amounts, threshold inhibitors have the ability to sequester metal ions via substoichiometric relationships. Compounds that exhibit the threshold effect include polyacrylates, polyphosphates, and phosphonates.

1. Formation of inorganic scale restricting pipe flow



Organic deposits

Examples of common organic deposits found in paper-mill systems include:

- Wood pitch
- Sizing agents
- Starch
- Defoamers
- Wax
- Ink
- Latex
- Wet-strength agents.

While inorganic deposits tend to be more of a problem in the stock and approach flow piping systems of the paper mill, organic deposits tend to be more problematic in the headbox, wet end, and press section of the paper machine. These contaminants form tacky deposits which can plug forming fabrics and wet press felts.

Wood pitch is a by-product of the pulping process. The form of wood pitch encountered in the paper mill system depends upon several variables including species of wood, pulping process used, temperature, and pH.

Additionally, any sudden changes in pH, temperature, or exposure to shear tend to aggravate pitch problems.

Sizing agents, starch, defoamers, and wet-strength agents are all common process additives. These additives along with wax, ink, and latex also enter the process through the use of recycled fiber and machine broke.

Control of organic deposits

Typical treatments used to continuously treat organic deposits vary depending upon the components of the deposit. The common treatments include fixatives, nonionic surfactants, dispersants, and adsorbents. Fixatives include alum and cationic polymers which are typically added in the stock system. Because organic deposits are generally anionic in nature, fixatives will neutralize the deposit's anionic charge and affix the particle to the fiber.

Due to the hydrophobic nature of organic deposits, nonionic surfactants which contain both hydrophobic and hydrophilic functionality can be used to emulsify and solubilize organic deposits. Anionic dispersants as discussed earlier work via charge repulsion to maintain the deposit components in a colloidal state. Adsorbents, including talc and bentonite clays, detackify organics by adsorbing onto and coating the surface of the organic deposit.

Biological deposits

Biological organisms found in paper mill systems can be divided into four broad categories: aerobic bacteria (survive in the presence of air), anaerobic bacteria (survive in environments without air), fungi (includes yeasts and molds), and in rare instances algae. Some common genera found in paper mill systems include:

- *Enterobacter*
  Anaerobic bacteria (slime former)
- *Pseudomonas*
  Aerobic bacteria (slime former)
- *Gallionella*
  Aerobic iron bacteria (slime former)
- *Desulfovibrio*
  Anaerobic bacteria (sulfate reducing)
- *Ascomycetes*
  Fungi.

Both aerobic bacteria and anaerobic bacteria are introduced into the paper mill system via the air, water, fiber, and process additives. Fungi are introduced into the system via the fresh water. Algae growth, though rare in paper mill systems, occurs in surfaces exposed to sunlight such as outdoor transparent holding tanks.

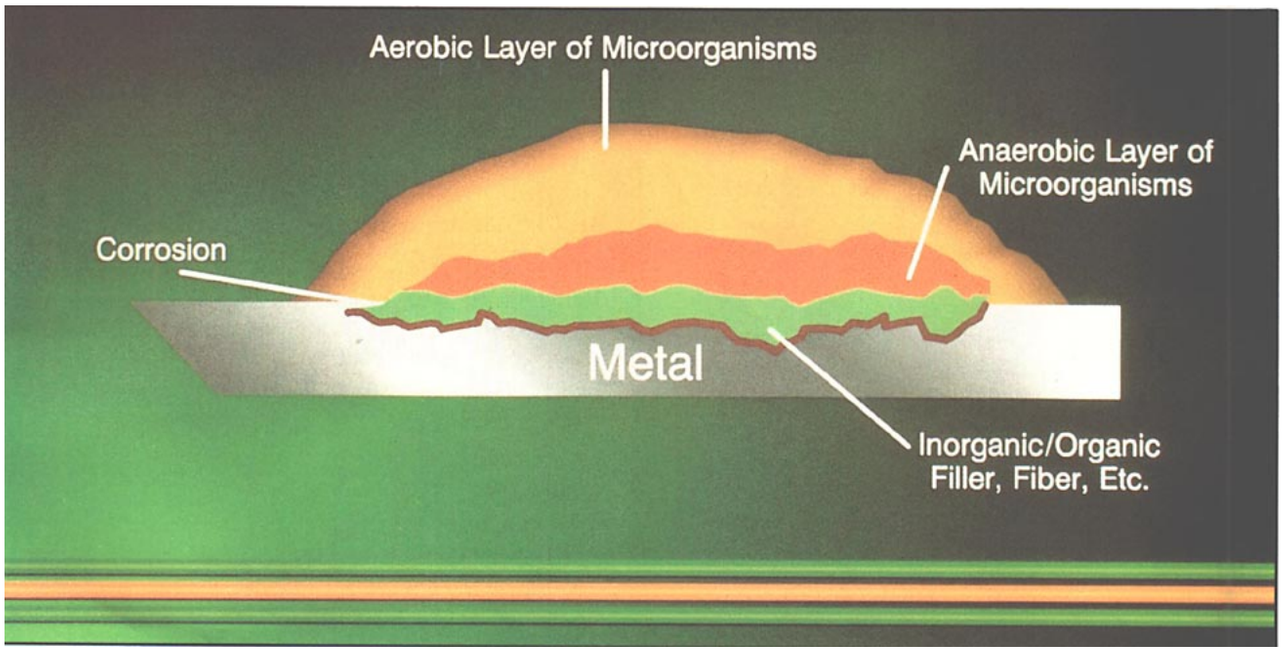
It is not unusual to observe high levels of organisms introduced into the system via the use of recycled fiber and untreated machine broke. Additionally, process additives such as starch, clay, and sizing agents offer excellent nutrient sources and growth medium for microorganisms.

Microorganisms in paper mill systems take two forms: planktonic (free swimming) and sessile (attached to a surface). Planktonic organisms do not readily cause problems in the system; however, in the sessile form these same organisms can become problematic.

Inorganic and organic deposits in the system offer a readily available food source for sessile organisms. They are able to attach themselves to deposit surfaces, and a number of these organisms classified as slime-formers are able to secrete a protective polysaccharide coating around themselves. This coating, known as biofilm, is very gelatinous in nature and easily traps other contaminants in the system. It is also very resistant to standard chemical treatments used to control biological organisms. The slime-formers, in combination with inorganic and organic process additives and contaminants, can form deposits which coat process equipment. These deposits create sheet quality and runnability problems.

In addition to slime formers, anaerobic bacteria can form underneath deposits. The cost common type of anaerobic bacteria found in paper mills is sulfate-reducing bacteria. This type of organism is capable of converting sulfate in the system to highly corrosive hydrogen sulfide.

2. Attack of metal by sessile anaerobic bacteria



This type of bacteria is characterized by a rotten egg odor, black color, and pitting corrosion. It is commonly found in dead areas of the system where there is little or no recirculation. In extreme cases, hydrogen sulfide gas generated by these organisms can be deadly (**Fig. 2**).

Control of biological deposits

Biological organisms are continuously controlled by the addition of biocides to the system. As paper mill systems have numerous populations of organisms within the system, treatment is usually based on control of a broad range of organisms. The majority of biocidal products on the market today cover a broad spectrum. These products are usually effective on a wide variety of organisms over a broad pH and temperature range.

Biocides used in paper mill systems can be broken down into two categories: oxidizing and non-oxidizing biocides. Oxidizing biocides include chlorine, chlorine dioxide, and chlorine donors such as brominated compounds. Non-oxidizing biocides include quaternary ammonium compounds, carbamates, and methylene bisthiocyanate.

When evaluating biocides, look for a product that has a broad spectrum of kill and will function within the temperature and pH parameters of the given machine system.

Additionally, the use of a dispersant or surfactant can enhance biocide effectiveness by eliminating biofilm, inorganics, and organics which can inhibit penetration of the biocide into the organism.

Downtime treatment

Downtime treatment is an integral part of any deposit control program. Downtime treatment, including boilouts and foam cleaning, should be done on a routine basis to purge contaminants from the system. Routine downtime treatment becomes even more critical in systems that are tightly closed and those systems using large percentages of recycled fiber. Deposits tend to build rapidly in these systems. If not periodically purged, these deposits form nutrient sites for the formation of biological slimes, corrosion, and odor.

Even the best continuous deposit-control treatment program will eventually reach a maximum limit of effectiveness. This occurs when the system reaches its saturation limit. At this point, further continuous treatment may be detrimental.

Deposits can break loose causing machine breaks, poor machine runnability, sheet contamination, holes, and poor-quality paper. Hence, it is important to implement routine downtime treatment as a part of a total system deposit-control program. For downtime treatment, proprietary blends of acid, alkaline, and solventized detergent products are generally used. The specific product depends upon the system parameters and nature of the deposits found in a particular system.

Conclusions

Since every paper machine is different, it is important to analyze machine operating variables and system contaminants thoroughly so that the appropriate continuous treatment program and downtime treatment program can be designed to fit the machine's individual requirements.

A successful deposit control program includes two phases of treatment: continuous treatment of the system while the system is running and downtime treatment of the system while it is shut down. This two-phase program works in synergy to inhibit the formation of inorganic, organic, and biological deposits.□

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