Controlling Limescale Deposition & Industrial Fouling

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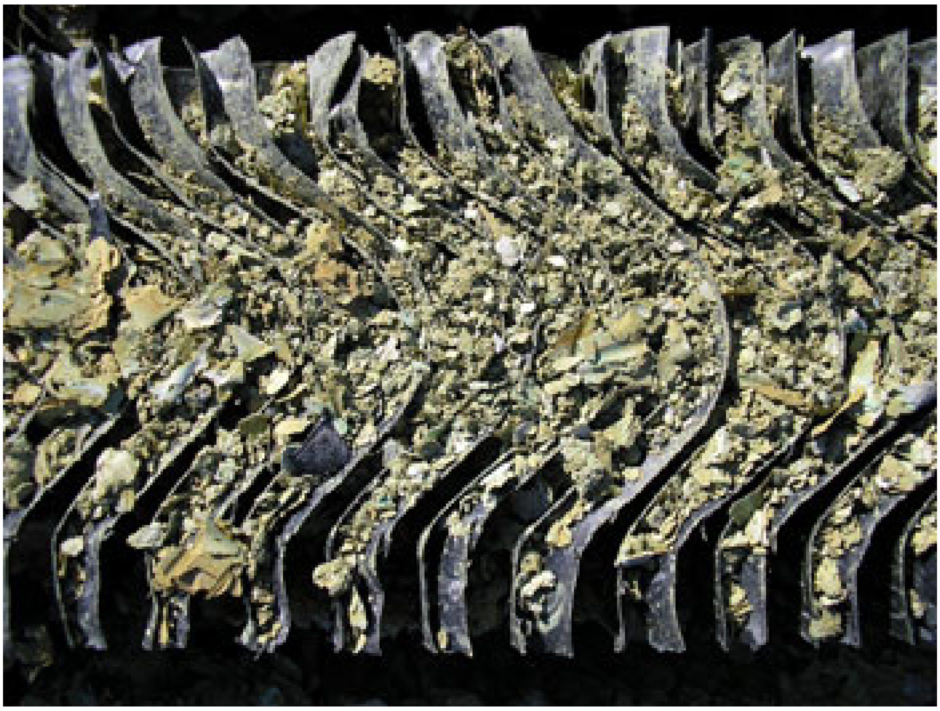

It costs U.S. industry billions of dollars a year to control and remove the limescale that builds up in industrial equipment such a heat exchangers, evaporative coolers, boilers, chillers and other water fed equipment. Oil wells, for example, face significant scaling problems from the highly mineralized water that are extracted with the oil. Limescale not only increases downtime, maintenance costs and causes the early renewal of capital equipment but also increases energy usage. Scale prevention can benefit industrial water users by minimizing or eliminating unexpected production shutdowns and by offering substantial savings to end users through water conservation.

Types of Fouling

Scale usually refers to an intimate mixture of sparingly soluble mineral salts. Mineral scale deposition occurs as a result of heat transfer or pressure changes. Calcium carbonate scaling from hard water, and calcium phosphate and oxalate formation in sugar refineries are examples. Other types of fouling include the growth of algae and bacteria (bio-fouling), the consolidation of loose particles (particulate fouling, e.g. corrosion by-products), and the accumulation of "coke" like deposits (an example of chemical reaction fouling).

What Can Go Wrong?

Calcium carbonate is the predominant component of the hard and tenacious scale deposit from water and is particularly apparent in processes involving heat transfer. A concentration of dissolved solids by repeated partial evaporation of the water is the main factor that causes calcium carbonate scale. Even soft water will eventually become scale forming when concentrated numerous times, i.e. two, three, four or even higher.

Process, maintenance and facility managers should be concerned about scale deposition. Deposits are an insulating layer on heat transfer surfaces. It is estimated that 40% more energy is needed to heat water in a system fouled with ¼ inch of limescale. This leads to more power being consumed or to the installation of heavier duty, more expensive heat exchangers to compensate. Scaled boiler tubes mechanically fail as a result of overheating and cooling tower plates can collapse due to the weight of scale deposits. Erosion damage can occur as a result of scale particles breaking loose and subsequently impinging upon other surfaces.

Pipework scale reduces the available cross-section area, and fluids are affected by increased pipewall friction. A larger, more power-consuming pump will be required to maintain throughput volumes but this may allow only a temporary solution to the problem. A plant that needs to be shut down for cleaning costs money.

The formation of a thin uniform layer of scale or wax can temporarily reduce steel corrosion but eventually stagnant conditions develop under the deposit and electrochemical reactions will corrode the steel surfaces. The result can be fluid leaks and equipment failure, which are potentially very dangerous. In the food industry, the incorporation of even undesirable trace particulates can lead to off-flavors or off-colors, reducing shelf life, or even making the product unsaleable.

Not only are plant and product integrity at risk but also personnel health and safety may be compromised. Safety valves or emergency process sensors that are fouled may not operate in an emergency. Overheated boilers have been known to explode. Failure to control bacterial growth in cooling water can create conditions hazardous to health (e.g. production of legionella Pneumophila) or, in anaerobic conditions, may allow the production of toxic hydrogen sulphide from sulphate reducing bacteria.

Recognizing Fouling

Because scales and other deposits generally form inside closed systems, it is not always evident that deposition is occurring. But some clues can provide the necessary evidence. It is useful to try to answer the following questions:

- Are energy/heating bills reduced immediately after cleaning the plant?
- Is it necessary to arrange significant planned and/or unplanned downtime?
- Are heat exchangers performing below design?
- Is corrosion a problem in the plant?
- Are there signs of unexpected deposit formation within the system?

The more times the answer is "yes," the more likely it is that there is fouling. If fouling can be controlled, there is the potential to save energy, prevent equipment failure, and reduce maintenance. Furthermore, a successful treatment strategy will maintain fluid flow, reduce corrosion effects, and provide a safer environment -- in addition to saving money.

Solving The Problem

A process audit would identify the extent of the current problem, the point in the system corresponding to initial fouling, and most useful, why there is a problem. From the evidence collated, it may be possible to suggest a solution without the need for expensive external control measures. Minor changes in the process temperature, pressure, pH or fluids composition could significantly reduce the fouling potential at practically no cost.

Treatment options include inhibitor chemicals, descalers, ion exchange, physical cleaning such as pipeline pigging, or the installation of permanent magnets, or electronic devices such as the patented, Scalewatcher computerized electronic water conditioner.

Although it is usually possible to find a chemical solution to a fouling problem, ever increasing environmental and safety pressures demand that chemical consumption be reduced wherever possible. Increasingly, restrictions are being applied regarding the use of chemicals, due to their environmental impact.

Physical Methods

A range of physical methods can be used to remove fouling deposits. Water jetting, sand or plastic-bead blasting can be used in accessible locations. Such methods are expensive and can cause abrasion of surfaces.

Magnetic & Electronic Descaling

Unlike other preventative techniques, these devices, such as Scalewatcher, do not stop precipitation but alter the shape of the crystals to reduce the adherence and build-up of deposits on the pipewall. Perhaps the most remarkable observation is that devices can affect descaling downstream of the point of installation; a softening and loosening of existing scale several weeks after installation is commonly reported.

To understand the mechanism, some knowledge of mineral scale precipitation is necessary. We know that in order to form a scale deposit three conditions must be met:

1. The solution must be supersaturated.
2. Nucleation sites must be available at the pipe surface.
3. Contact / residence time must be adequate.

To prevent scale it is necessary to remove at least one of these pre-conditions.

Clearly contact time is not an alterable factor. To be effective any device must therefore affect either the super saturation value or the nucleation process.

The direct effect of the electronic device described above is on the nucleation process and in particular to enhance initial nucleation through the creation of new nucleation sites within the bulk fluid flow. This is controlled precipitation. Crystal growth then occurs at these points of nucleation and not at the pipe wall. Suspended solids increase with a corresponding drop in the level of super saturation, and these effects have been observed in the field.