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Featured Excerpt:

Optimum Heat Exchanger Performance Depends On Clean Tubes

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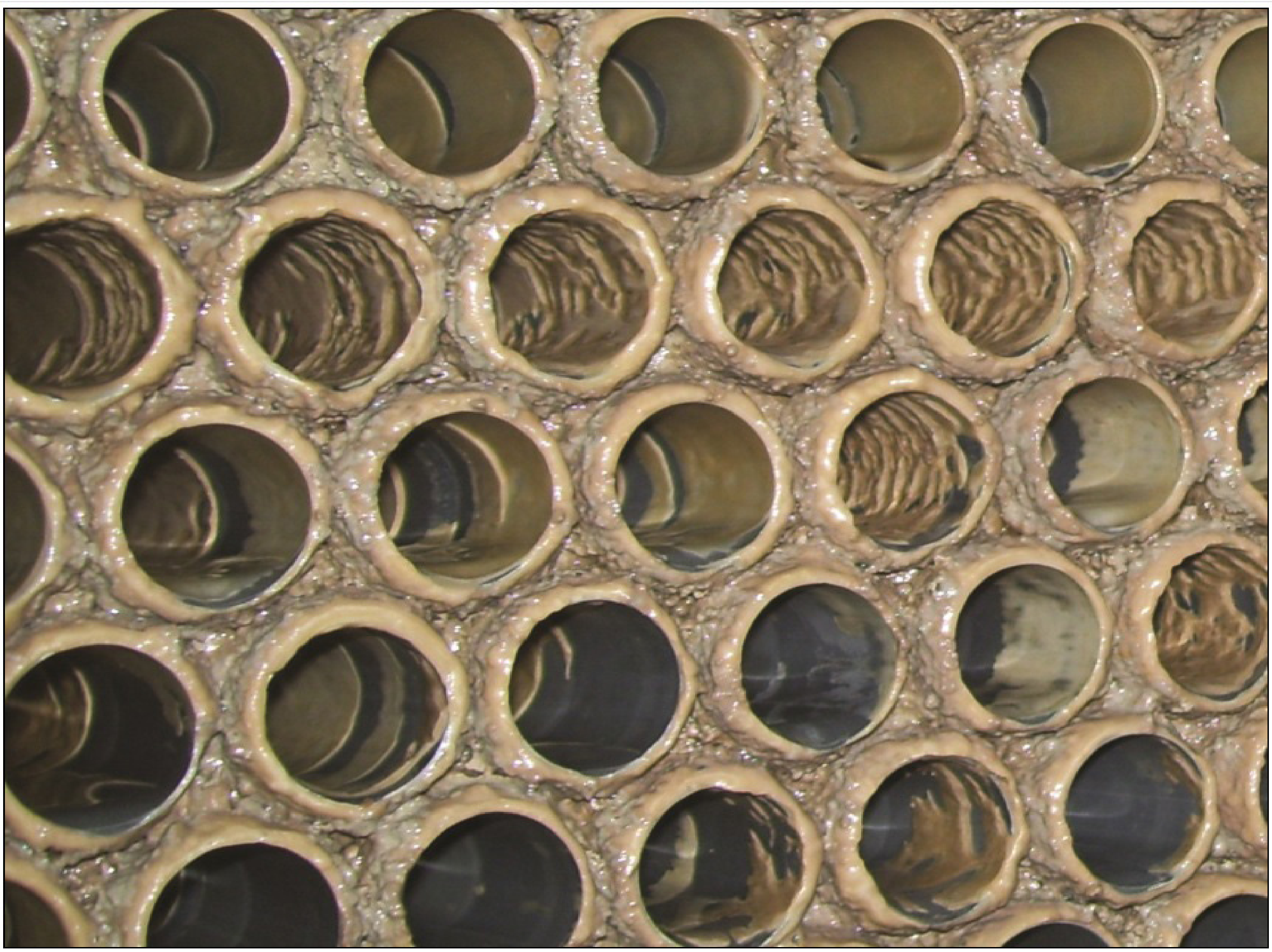

Optimum Heat Exchanger Performance Depends On Clean Tubes

By Jennifer Larson, Conco Industrial Services

The correlation between heat exchanger tube condition and unit performance is well-known throughout the industrial community. Dirty tubes reduce unit performance and can lead to equipment down time and lost revenue. If tubes are not properly maintained, they will become fouled with deposits. As deposits build up in the tubes, heat is not transferred efficiently, compromising the heating and cooling process. This will result in a noticeable reduction in unit output. In addition, under-deposit corrosion can occur as the deposition material causes damage to the tube wall. A breach or tube leak can not only allow material to cross through the tube wall contaminating product, but can cause damage to other components in the unit system as well.

When selecting the most advantageous cleaning method, many factors must be considered. The type of heat exchanger, tube material and dimensions, type of fouling present in the tubes and environmental regulations all play a role in determining what type of cleaning method should be used to successfully remove the deposit.

Types of Fouling

Fouling can be broken down into two categories: macro fouling and micro fouling. Macro fouling includes debris that can be either biological or inorganic, such as barnacles and mussels, leaves and sticks, synthetic waste, litter and detached internal parts of components. Micro fouling includes things such as algae, bacteria, scaling, crystallization, particulate fouling, corrosion fouling, chemical reaction fouling and solidification fouling. The resulting build-up from each of these fouling types can range from soft and sticky to extremely hard and dense and often depends on the geographic location and the cooling water source of the plant as well as the type of product that the unit is processing.

Industrial plants may use river water (fresh water), coastal water (sea water) or well water as their source of cooling water. The unique chemistry of a water source presents a unique set of fouling problems. Coastal southeastern plants, for example, usually experience problems with particulate fouling, which can be microbiological growth or the build-up of sediment in the tubes, whereas American Midwest plants often find that calcium carbonate deposits are the primary concern.

Particulate fouling is caused by the deposition of particles that are suspended in the flowing fluid on the inner walls of the tubes. Over time as the deposits increase, they begin to restrict the flow within the tubes of the heat exchanger and decrease the amount of heat that is able to be transferred. If left unmitigated, particulate fouling may cause damage to heat exchanger tubes and adjacent components.

A heat exchanger's inlet tubesheet is the entry point into hundreds or even thousands of heat exchanger tubes. Macro fouling of this important gateway can cause heat exchanger efficiency problems. When sea water is used for cooling, the most frequent culprits of macro fouling are aquatic wildlife and shellfish. Debris often makes its way to the tubesheet in spite of filters that are in place at most plants, causing partial blockages and reduced flow through the heat exchanger tubes. The resulting partial flow blockage will allow particulates to accumulate, and local flow around

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Heat Exchanger Tube Shooting

HydroDrilling a Sulfur Recovery Unit

Macro Fouling Inhibiting Flow

Scale Build-up on Tubes

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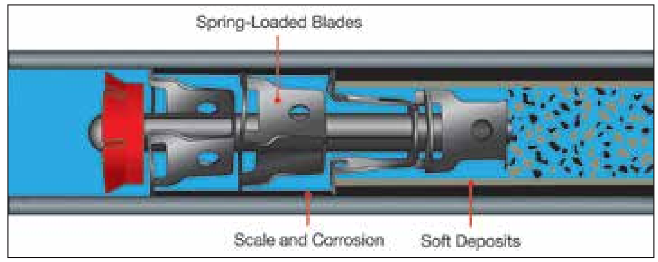
the deposits may cause erosion-corrosion. To ensure that the tubesheet is free and clear to operate, debris screens and filters should be inspected and cleaned on a regular basis.

High bacteria content in the cooling water and low velocity flow are primary causes of microbiological fouling. This type of fouling can result in substantial particulate deposition as fine matter adheres to the sticky biofilm coating of bacteria on the tube wall. The thickening deposits produce corrosive bacterial by-products that can eat through the base metal of the heat exchanger tubes. Calcium carbonate deposits, on the other hand, occur when the saturation point of dissolved constituents in the cooling water is exceeded and scale or crystallization builds up. Scale deposits are known to be some of the most tenacious heat exchanger tube fouling issues. They are also more likely to form in high temperature conditions, and like other types of fouling, scale deposition can cause under-deposit corrosion and even erosion-corrosion around the scale itself. Removal of the scale is necessary to return the heat exchanger to optimum efficiency. Mechanical tube cleaners with precision cutting blades have been engineered to break through the hard shell-like coating, while safeguarding the valuable tube wall.

Mechanical tube cleaners can also be used to combat chemical reaction and freezing fouling. Chemical reaction fouling occurs to varying degrees in any process environment in which hydrocarbons, or other reactive organic species, are heated. This includes refinery heat exchangers, steam cracking furnaces and food processing plants. Freezing fouling occurs when a portion of the hot stream is cooled to near the freezing point of one of its components. Some examples include the solidification of paraffin from a cooled petroleum product or the freezing of polymer products on the heat exchanger surface. In both cases, if the fouling is extremely tenacious, drilling in conjunction with a flow of low-pressure water (hydrodrilling) may be the most effective method of cleaning.

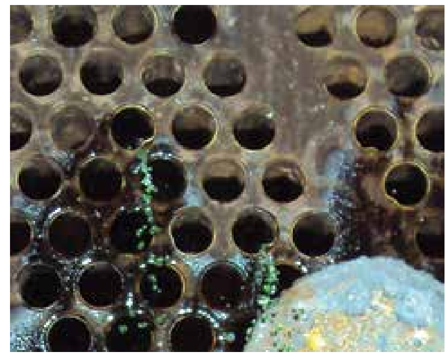


Industry Standard Metal Tube Cleaner

Implications of Tube Metal Type

Not all heat exchanger tubes are alike. Knowing what they are made of provides a necessary understanding of why some heat exchanger tubes are more prone to fouling. The four most common materials used for heat exchanger tubes are: stainless steel, carbon steel, copper and titanium.

Stainless steel tubes contain more than 10.5% chromium, which reacts with oxygen in the air or water to form a protective passive layer. The passive film is meant to be self-healing if damaged. Generally these tubes are considered to be high-performing. The most important consideration for stainless steel tube maintenance is keeping them clear of slime and microbiological deposits. Carbon steel on the other hand is composed simply of iron and carbon. Carbon steel tubes are known for their durability, wide functionality and strength. However, the biggest drawback of carbon steel tubes are their predisposition to corrosion. Copper is a natural antimicrobial material, and while copper tubes disrupt the growth of some microbes, they are also prone to the formation of a hair-like oxide deposition. If left unmitigated, this deposition will disrupt heat transfer. Titanium has good heat transfer characteristics, which make it an ideal metal for heat exchanger tubes. In addition, tubes made from titanium do not corrode. Titanium tubes have a longer incubation period before the first cleaning is needed, after which, fouling will occur at the same rate as stainless steel tubes.



Tubesheet Damaged by Hydroblaster

Stainless Steel Tube with Scale Deposits

The Importance of Cleaning

There are three primary approaches to cleaning fouled heat exchanger tubes: chemical dissolution, hydroblasting and mechanical tube cleaning.

The use of chemicals can be complicated. While each fouling scenario will require a unique chemical

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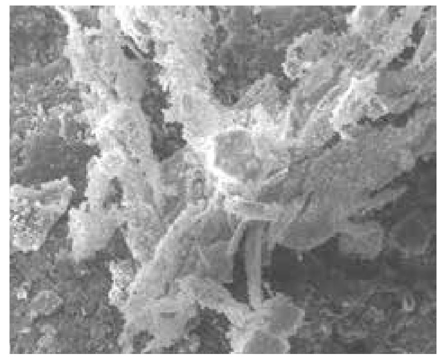
formulation and cleaning strategy, environmental regulations may restrict the use of any given chemical. Further, due to these same environmental regulations, there can be economic costs associated with the collection and disposal of used chemical agents. Often when chemically cleaning, high volumes of water are used to flush the chemical agents out of the tube to remove any residual deposits and avoid acid degradation of the tube metal. While necessary to protect the tubes from acid degradation, this flushing action generates vast amounts of wastewater which, like the used chemical agents, must often be collected and properly disposed of, adding to the economic cost of the chemical cleaning operation.

How effective hydroblast cleaning is depends upon four factors: the travel speed of the lance, the nozzle used, the type of deposit and fouling conditions of the tubes. A typical hydroblasting operation will clean using large volumes of water at pressures from 10,000 to 40,000 psi or more. At these pressures, the jet of water exiting the hydroblast nozzle can cut and kill. This requires hydroblasters to maintain a large safety perimeter or footprint to protect workers, which can disrupt nearby plant operations. The hydroblast method can also be dangerous for wall thinning and tube-to-tubesheet joints. Operators must be careful not to allow the high-pressure waterjet to damage these vulnerable areas of the heat exchange. In addition, if tube coatings are in place then hydroblasting cannot be used.

Mechanical tube cleaning is safe, fast and effective. There are three basic types of mechanical tube cleaning systems on the market today: tube shooting, tube brushing and tube drilling. Depending on the type of deposit and the extent of the fouling, these systems are often used in combination to provide a superior clean. All three methods work in conjunction with low-pressure water (under 700 psi) to remove deposits. By using safe, low-pressure water and compact equipment placed close to the heat exchanger, mechanical tube cleaning systems require a very small safety perimeter or footprint. They are clean-in-place systems and do not require the dismantling or moving of the heat exchanger. Cleaning in place reduces the risk of accident, injury and component damage. Also, because they are clean-in-place and require only a small footprint, there is little to no disruption to other plant operations. Furthermore, mechanical tube cleaning uses far less water than hydroblasting. If hydroblasting a given heat exchanger at 20,000 psi consumes 48,000 gallons of water, cleaning the same unit with mechanical tube cleaners at 500 psi would only consume 5,000 gallons of water, a savings of 43,000 gallons. That equates to 90% less wastewater to be collected and processed, saving money.

There are numerous cleaning strategies available that are safe and effective on all types of deposits. By selecting the best cleaning strategy with the appropriate combination of mechanical tube cleaners, fouling deposits, corrosion products, physical obstructions and tube surface roughness will be removed quickly. Most importantly, mechanical tube cleaning improves heat transfer and provides protection from under-deposit corrosion. Once tubes are cleaned with mechanical cleaners, water flow will be restored and the heat exchanger returned to test ready standards. In a refinery or petrochemical plant, the quick turnaround for mechanical tube cleaning can reduce overall outage time by up to 70%, resulting in additional days of production and increased profits.

Under Deposit Corrosion - Pitting Due to Manganese Deposit



Silica Deposit at 500X Magnification

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