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# INNOVATION AND EFFICIENCY: LOW-PRESSURE WATER MECHANICAL CLEANING OF THE HEAT EXCHANGER CASES IN HEAT EXCHANGER CLEANING

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#### ABSTRACT

The consequences of heat exchanger tube fouling can be far-reaching and severe. Fouled heat exchanger tubes have a negative impact on the heat transfer and production capacity of the units in which they reside in numerous industrial settings. The added costs of additional fuel, meeting power requirements and unit downtime can be a tremendous expense to plants and operators. Additionally, a heightened awareness of the environmental impact of poorly performing heat exchangers has revealed alarming data on the global impact of fouling. Studies point to the role of fouling and the sizeable contribution of it to global CO<sub>2</sub> emissions. There is no better time for our industry to respond to the unique challenges of today's production environment, and we can do so by committing to being innovative and smarter in our approach to heat exchanger maintenance. Fortunately, there has never been a better time to clean the heat exchanger. This paper will discuss the significant value of newer and innovative low-pressure water mechanical cleaning systems and how they compare to common high-pressure methods. The benefits of specific low-pressure methods will be introduced and discussed as well as their positive impact on safety and the environment.

#### **INTRODUCTION**

Unfortunately, heat exchangers of every variety and in every theatre of industry are prone to fouling. The nature of the fouling will always depend on the fluids or gases flowing within and over the tubes. The reduction in heat transfer that results from fouling processes invariably has an impact on production capacity and this will impact the cost of the final product. To reduce this impact, heat exchanger performance must be monitored. Early identification of fouling characteristics and a fundamental knowledge of cleaning system capabilities are essential in determining the most effective and intelligent cleaning technology available.

*Innovative...and safe.* In recent decades, conventional approaches to heat exchanger cleaning have been improved upon, and new and innovative cleaning methods have been developed that provide unprecedented results. Heat exchanger cleaning should be a safe proposition and labor force and component safety are vital to consider when choosing how to clean. Fortunately, recent strides in cleaning technology with low-pressure water provide for

very safe cleaning applications. Low-pressure water means less pressure and a smaller safety zone. Figure 1 shows a typical safety zone for a low-pressure application, while Figure 2 shows the larger safety zone required for highpressure applications. High-pressure water applications of the past would use 10,000-50,000 PSI. Low-pressure mechanical cleanings use a maximum of 600 PSI, and require significantly smaller crew sizes than high-pressure applications. In low-pressure cleaning, it is no longer necessary to dismantle the heat exchanger and move it to a separate work zone, so cleaning is done in place. This reduces the risk of accident, injury and component damage.

Environmental Impact. No discussion of the best way to clean a heat exchanger can proceed without a consideration of environmental impact. In fact, one goal of the conference for which this paper is being presented is a call for heightened awareness on the part of industry to the environmental impact of fouled heat exchangers, and the role of impaired heat exchanger function in global CO<sub>2</sub> emissions. Clean heat exchangers simply work better. There is another obvious environmental advantage to low-pressure water cleaning methods: water conservation. Typical lowpressure water cleaning of 5,000 tubes will require approximately 8,750 gallons of water versus 193,500 gallons of water in a hydroblast cleaning of the same size unit (See Table 1, Water Consumption). Newer, techniques using no water also enable some toxic materials to be reduced to dust and hauled away in a sack or drum, and there is often little-to-no water discharge. Less water use means less to clean up or to reclaim in the post-cleaning phase.

*Time is Money.* Giving consideration to the environmental impact of any cleaning system is a best practice, but the reality is that for many plants and operators, budget constraints will drive decision-making on how to clean. For most plants, time really is money. Because new and innovative low-pressure cleaning applications require far less unit downtime, it is also the cleaning method that is economically advantageous for industry. Heat Exchangers are cleaned where they reside, in place and intact. There is no time wasted and labor costs associated with disassembly of the heat exchanger, moving the exchanger to a separate cleaning pad, and then reassembly. Time for the cleaning process can be 70% less than when using high-pressure

water—often hours versus days with the TruFit mechanical tube cleaning system. The mechanical cleaners are propelled through the heat exchanger tubes at 20 feet cleaned per second. Figure 3 demonstrates the typical duration of lowpressure water versus high-pressure water applications and the time expenditure associated with getting your process back on-line and producing faster.

*The proof is in the performance*. Once a heat exchanger is mechanically cleaned, plant units immediately recover lost production capacity, as tubes are returned to as new condition. Tubes are cleaner and moving forward they require less frequent maintenance. What's more, reduced corrosion rates means longer component life, and more efficient heat transfer means significantly improved process economics.

# HIGH-PRESSURE WATER VERSUS LOW-PRESSURE MECHANICAL CLEANING

High-pressure water cleaning applications have been the most common method for cleaning heat exchangers and condensers in a variety of industrial settings, but there are significant trade-offs associated with this approach. The high-pressure water footprint is sizable. Multiple water trucks and apparatus arrive on site, numerous technicians must be present to ensure that the large safety zone is maintained, the duration of cleaning is lengthy compared to other methods because water alone is not the best cleaning catalyst, and finally the environmental impact of using thousands of gallons of water to clean one heat exchanger is a scenario drawing greater scrutiny than ever. In draughtstricken parts of the world where industry and agriculture are bound by strict water usage restrictions that can come with penalties, the water usage requirements of highpressure water cleaning have made this approach obsolete and unviable.

Newer cleaning systems using low-pressure water operate at far lower water pressures than high-pressure hydroblasting. A typical water pressure for a low-pressure application is 600 PSI compared to the average 10,000-50,000 PSI used in hydroblasting. What's more, lowpressure water systems have a much smaller footprint than high-pressure methods because cleaning components are smaller and more specialized. Fewer technicians are needed which provides for less unit congestion, and this confers a reduced safety risk for the labor force and the equipment being cleaned. The environmental impact of low-pressure water use is far reduced than with other methods. Lowpressure mechanical cleaning uses 97% less water than traditional high-pressure methods, and that equates to reduced exposure to contaminated waste water for personnel and nearby aquifers.

Low-pressure cleaning systems such as TruFit mechanical tube cleaners, Hydrodrill, and the Excaliber pneumatic flex drive system often provide a superior clean to high-pressure methods. Further, low-pressure mechanical methods are effective at cleaning the most tenacious fouling scenarios: particulate and biological fouling, calcium carbonate, asphalt, baked-on hard deposits, acrylic, highdensity polyethylene, iron oxide and others. Tubes cleaned with low-pressure water are usually ready for Eddy Current or other non-destructive testing and require no additional cleaning or preparation. The anecdotal record speaks to the immediate recovery of production capacity and heat transfer in the aftermath of low-pressure mechanical cleaning, and these results are achieved safely, quickly and efficiently.

In a comparison of TruFit mechanical tube cleaners versus high-pressure water cleaning of 1,000 heat exchanger tubes, the low-pressure TruFit method used a total of 1,750 gallons of water. The high-pressure hydroblast method required 560,608 gallons of water. This large disparity in water usage despite the superior cleaning results of the low-pressure method is in part explained by the differing mechanics of the two methods. The TruFit mechanical cleaning method pumps water for only the three seconds it takes for the mechanical cleaner to be propelled through the tube. The water flow is then stopped. The Hydroblast method pumps water 70% of the time the system is operating which explains the dramatic difference in water use. See Figure 4 for a comparison of tubes cleaned with low-pressure mechanical cleaners and high-pressure water.

# CLEANING SOLUTIONS AND CASES

Shell and Tube Heat Exchangers. Cleaning heat exchangers in a timely manner and restoring heat transfer capability is vital to the operation of any plant. The old cleaning method of disassembling the heat exchanger, removing and transporting the bundles to a restricted access cleaning area for high-pressure water cleaning is timeintensive and expensive. High-pressure water applications require a large safety zone attended by numerous technicians. The innovative solutions for shell and tube heat exchanger cleaning are low-pressure water mechanical cleaning tools that are "shot" through the tubes at a rate of two seconds per tube. Because low-pressure mechanical cleaning has a very small footprint, many heat exchangers can be cleaned, in place and intact, minimizing safety risks and reducing labor costs.

**Sulfur Recovery Units-Reboiler.** Historically, sulfur recovery units have been difficult to clean. This is due to the proximity of the heat exchanger to the boiler, and because the boiler operates at very high temperatures, it requires ceramic ferrules on the tube ends and refractory brick and mortar on one tube sheet. In this environment, deposits can be up to ½ inch thick and coke-like in nature.

The conventional approach to sulfur recovery unit cleaning is to pull the heat exchanger out of the boiler, move it to a pad, and blast it with high-pressure water for several days. This approach requires disassembly of the boiler drum, and removal and replacement of the refractory and ferrules. The results of this cleaning protocol are mediocre, and, afterward, the tubes are typically not clean enough to be tested.

The most innovative and effective approach to cleaning sulfur recovery units is liquid nitrogen cleaning. Nitrolance technology can be used at locations where use of water is not an option and unit tubes are cleaned to a level that supports remote field and Eddy Current inspections. Liquid nitrogen cleaning is highly efficient. See Figure 5 for a comparison of before and after cleaning with Nitrolance technology. Post-cleaning residue is completely dry and easily collected and disposed of. The environmental benefits of liquid nitrogen cleaning are in keeping with today's efforts to conserve water, and because there is no liquid waste, concerns about wastewater contamination are mitigated. The post-cleaning phase requires the simple removal of drums of dry waste. There is zero transportation time and expense, and no expense associated with rebuilding of components. Compared to typical hydroblast applications where cleaning can take an average of twelve days, cleaning applications with liquid nitrogen take an average of two days.

**Fin Fan Exchangers.** In the external fins of these aircooled exchangers, dust and debris can settle, while the inside diameter of the unit tubes become jammed with sludge. The conventional cleaning response to this scenario has been the use of a fire hose, foam or hand-held lance. These methods are not particularly effective, and, worse, often result in damaged fins, reduced airflow and the remaining sludge from the tubes is difficult to remove. The sludge is dumped back into the internal headers, perpetuating the cycle of clogged tubes and poor performance.

FinTech technology is an innovative automated cleaning system that cleans the fins with a low operating pressure that minimizes any bending of fin blades. The FinTech is computer controlled and uses a water jet carriage system that moves at a consistent speed across the bundle. The consistency of the speed and water flow results in a uniform and consistent clean. The water jets can be manipulated to match the geometry and features of the fin network, optimizing the washing effect and protecting the fins from damage. The focused array of water jets distributes water deep into the bundle, and the water used in this technology contains no additives so there is no need to collect and dispose of wastewater. Moreover, the FinTech system is safe for the operator and the components, no scaffolding is required, and it is applicable in both horizontal and vertical applications. It is then recommended to follow with mechanical tube cleaners combined with a Tube Bridge to access the inner diameter of the tubes, which will keep sludge and other contaminants from entering the header system. See Figure 6 for a representation of the Tube Bridge component. The benefits of FinTech technology are fast and thorough cleaning with no damage to fins, and safe, effective cleaning of the tubes and Tube Bridge without contaminating the process stream.

**Catalytic Reactor Vessels/Exchangers.** These complex vessels can have over 7,000 tubes that become plugged with catalyst, mixing springs and rings, and can often take weeks to clean. They are often tall units, 40 feet high or more, and must be cleaned from the top. The challenges associated with cleaning this type of unit means that by the time maintenance occurs, tubes can be badly clogged. The conventional cleaning practice has been to remove the top of the exchanger, scaffold is erected, several trucks work for upwards of ten days, leaving behind tubes that are still clogged, and tubes with lances that became

wedged and bound in catalyst. This is an expensive, lengthy and less effective cleaning protocol.

A better solution applies a combination of Hydrodrill and TruFit technologies to successfully unplug and clean all tubes in these exchangers. Hydrodrill technology uses lowpressure water with a pneumatic motor to safely drill through all blockages, removing broken and embedded lances from prior cleaning attempts. The results of this innovative cleaning approach are numerous. Efficiency: faster, better results with a significantly smaller workforce. Safety: safer technology with a much smaller safety zone, and one-fourth the labor force means fewer workers being exposed to risk. Because Hydrodrill and TruFit technologies use a fraction of the water of other methods with a smaller force, low-pressure mechanical cleaning is labor environmentally responsible cleaning that is effective and practicable in all industries the world-over.

### CONCLUSION

In heat exchangers the world-over, there are substantial fouling problems that cost industry billions of dollars in lost production capacity. This isn't just bad for business; it's harming our environment by contributing to global CO<sub>2</sub> emissions. To improve the performance of fouled heat exchangers, operators must first understand the nature of the fouling, and then commit to better stewardship of their heat exchangers. Fortunately, there has never been a better time for heat exchanger maintenance. Innovation of new and improvements of existing cleaning technologies are resulting in better outcomes with less waste, which is good for business and the environment. Low-pressure mechanical heat exchanger tube cleaning methods combine new and innovative technologies, such as hydrodrilling and liquid nitrogen, with the long-standing effectiveness of mechanical cleaners to offer a next generation tool kit of highly effective and responsive heat exchanger cleaning for any plant that houses a heat exchanger.

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Figure 1.



Figure 2.



# Table 1. Water Consumption



Figure 3.



# Figure 4.



Figure 5. NitroLance Cleaning Results



Figure 6. Tube Bridge

