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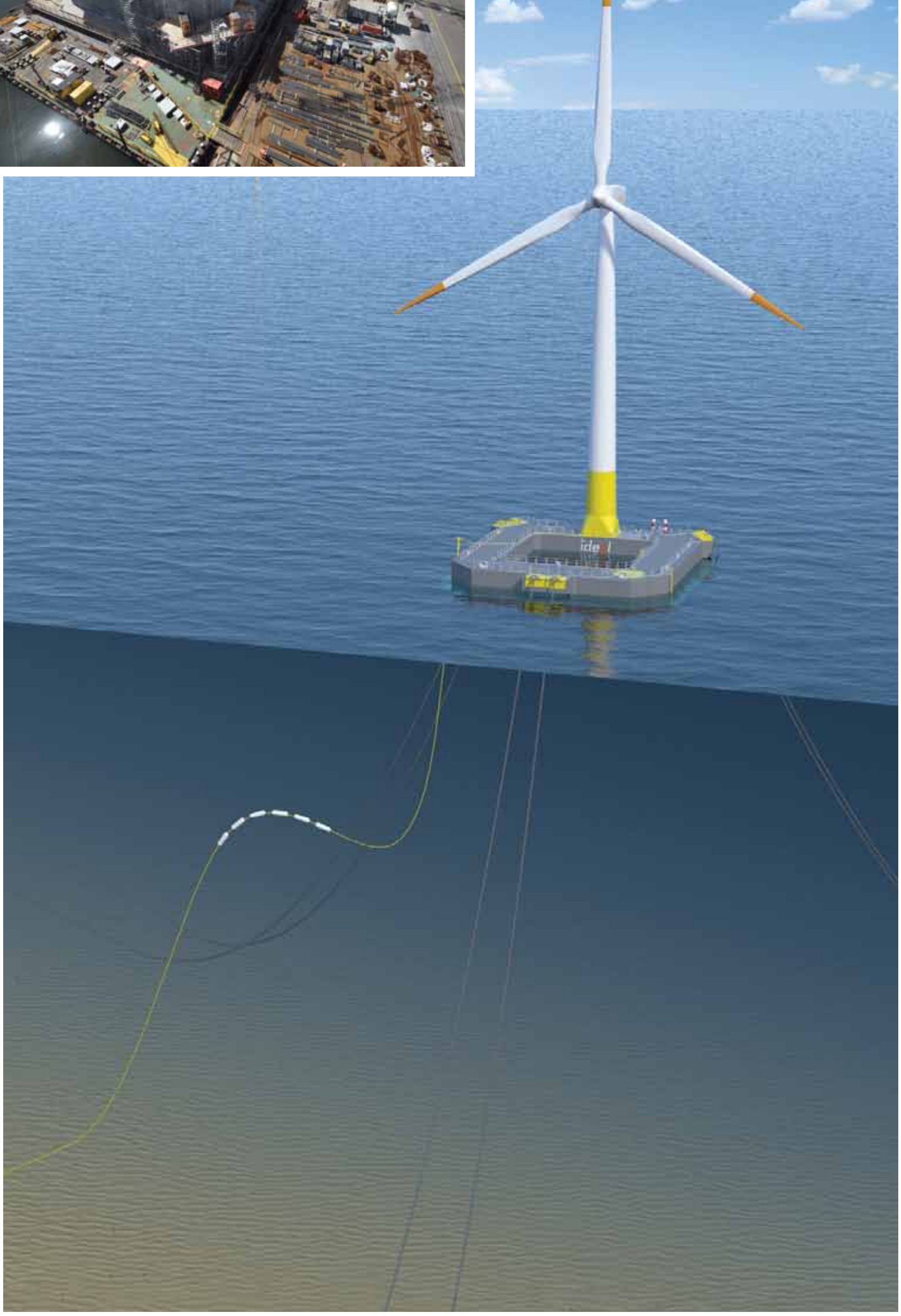

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FLOATING WIND: READY FOR THE LAUNCH FROM LAB-SCALE CURIOSITY TO CONCRETE REALITY?

How reducing the pressure can increase the effectiveness

Fouling of condenser tubes over time is inevitable, but the techniques to deal with the problem have greatly improved over the years. Particularly effective is a process in which mechanical cleaners/scrapers are propelled through the tubes using water at relatively low pressure, much lower than that typically used in hydroblasting, resulting in a number of major benefits, including reduced risks and less water consumption.

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A big step towards improving energy efficiency at your power plant begins with understanding how essential the plant condenser is to the overall operation of the unit. Overlooking the performance of the condenser can be costly. It is an unwelcome reality that condenser tubes of every material and in every theatre of industry are prone to fouling. The nature and severity of the fouling will vary depending on the attributes of the fluids flowing within the tubes, and on any mitigation efforts the plant has taken thus far, but the implications for unit performance are universally negative.

The consequences of condenser tube fouling can be far-reaching and severe. When condenser tubes foul, deposits form a barrier between the cooling water and the tube wall, causing a reduction in the heat transfer rate and production capacity of the unit. As these deposits thicken over time, the flow of water is restricted, further reducing heat transfer. With reduced heat transfer comes a rise in unit backpressure and a loss of megawatt output and ultimately revenue. If fouled condenser tubes are left unmitigated, deposits can cause pitting, tube failures and forced outages.

Engineers working in power generation understand that there is a direct correlation between main condenser cleanliness and megawatt output. While every effort can be taken to keep condenser tubes clean, from water chemistry adjustments to the installation of debris filters, inevitably condenser tubes will foul. Fortunately, enhanced fouling mitigation methods are better than ever, providing plants safe, fast and highly effective ways of addressing the issue.

The propensity for fouling

No matter what the configuration of the condenser is in your plant, there is always a propensity towards tube fouling. The cause of deteriorating condenser performance is often progressive fouling of internal tube surfaces, and is frequently found within a condenser when reduced heat transfer capability is observed. Condenser tubes are fouled when unwanted material has accumulated on the tube wall, and fouling almost always interferes with the efficient operation of the condenser. Fouling results in higher backpressure in the condenser and less efficient turbine performance, requiring increased fuel and even limiting generation capacity. Tube fouling is a perpetual problem with condensers, but careful management of condenser maintenance can significantly contribute to improving a unit's economic performance.

Condenser tube fouling occurs mostly on the interior of the tubes, and falls into five categories: microbiological; scale; deposition; corrosion products; and tubesheet pluggage.

- **Microbiological** fouling routinely occurs in plants that use seawater or river water in their circulating water system, and can consist of marine plants and animals, mud and organic slime. This type of fouling is extremely common in condenser tubes because bacterial species will easily colonise and grow on the inert substrates of the metal tubes, and the elevated temperature at the interior wall of the condenser tubes is ideal for growth of certain bacteria. Even the thinnest layer of microbiological fouling can be detrimental to heat transfer because the slime consistency of the fouling has poor heat conduction chracteristics.
- **Scale deposits** occur when there are high temperature conditions and dissolved mineral content, such as when calcium carbonate and calcium phosphate are present. Depending on the mineral content and the thickness formed, scale fouling can drastically reduce heat transfer in the condenser. If left unattended, crevice corrosion of the tube can form beneath the hard scale coating.
- **Deposition** fouling of particles onto the interior of the tube wall generally occurs when water flow rates are not adequate to keep particles in suspension. Common deposits include sediment, silt, diatoms, coal dust and minerals. Areas of low water flow in the condenser often result from partial blockage on the tubesheet or a tube obstruction. Particle deposition alone may not cause a significant loss in heat transfer, but may serve as an initiation site for crevice corrosion.
- The formation of **corrosion products** within condenser tubes is a potentially serious fouling scenario that is more likely to occur when source water for the plant is corrosive. Corrosion products can become relatively thick on the surface of some condenser tubes, particularly tubes made of copper alloys. Tubes that contain hard scale fouling are prone to copper oxide growth, and in some cases, a thin surface scale will inhibit heat transfer and promote crevice corrosion.
- **Tubesheet pluggage**. The inlet of the condenser tubesheet is vulnerable to blockage by a variety of materials and debris, including rocks, concrete, broken pipes, cooling tower materials like plastic fill and wood, chunks of ash and coal, rusted metal, leaves and other vegetation.

Conventional tube cleaning methods

Preventing or minimising fouling in the first place is a very good way to approach condenser maintenance, while on-line foulant removal measures can be implemented to minimise accumulation, and are more successful when the probable foulant is known.

Water chemistry modifications, such as reducing the pH of the circulating water by injecting additives, have been used to reduce calcium carbonate and calcium phosphate fouling. On-line mechanical cleaning systems, such as abrasive sponge balls or recirculating cleaning tools, can be effective with very soft deposits and with some microbiological fouling. On-line systems are less effective when there is hard scale fouling or corrosion in the tubes. Some plants have opted to use high doses of biocides for a short period to remove biofilms from condenser tube walls, although many microbiological growths are resistant to biocides.

For many plants, fouling processes have been underway for some time, and more aggressive fouling mitigation methods need to be employed. Removal of fouling from the condenser tubes when a unit is off-line is usually the most effective approach. When the unit is off-line, condenser tubes can be directly evaluated for fouling and overall condition, and this allows an

Figure 1. Metal scraper

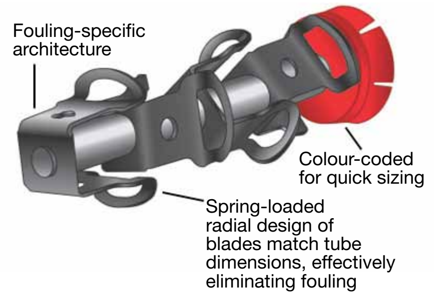


Figure 2. Wire brush

accurate diagnosis of the problem and a precise mitigation strategy.

Chemical removal of corrosion and scale can be successful, provided the process is correctly designed and implemented. There are drawbacks to chemical cleaning, though, including: safety; cost; waste disposal; duration of cleaning; incomplete foulant removal; and damage to the base metal of the condenser tube.

There are several off-line mechanical cleaning techniques that are commonly used to remove foulants. Metal mechanical scrapers have been developed to remove virtually all types of foulants, even hard mineral scale such as calcium carbonate. Figure 1 shows the industry standard metal mechanical scraper. Typically, scrapers are propelled through the length of the condenser tube with pressurised water at about 10-20 feet per second and loosened debris is flushed from the tube with the scraping process. The advantage of metal scrapers is that they are effective at removing a variety of common foulants, and careful evaluation over many years has determined that there is virtually no risk of base metal damage when well-designed cleaners are used properly.

Figure 2 shows a stainless steel brush for mechanical cleaning. Like the mechanical scrapers mentioned above, wire brushes are propelled down the length of the condenser tube with pressurised water. Brushes are particularly useful with tubes that have inlet-end metal inserts or inlet epoxy coating, because these can reduce the internal diameter of the tube.

High-pressure water cleaning of condenser tubes, commonly called hydroblasting, is a useful strategy with particularly soft foulants like particulate deposits and microbiological films. However, using hydroblasting for harder and more adherent fouling conditions will result in incomplete cleaning.

When high-pressure water is deployed, caution is needed. If the stream of water is allowed to pause for too long, it can quickly cut through softer condenser tubing like copper alloys. Also, hydroblasting is not recommended for use with condenser tubes that contain inlet-end metal inserts or coatings, as the blast of water can damage the coating or inserts.

Benefits of lowering the pressure

In recent decades, conventional approaches to condenser tube cleaning have been improved upon, and new and innovative cleaning methods have been developed that provide unprecedented results.

Recent strides in mechanical cleaning using low-pressure water provide a very safe and effective cleaning technology.

Low-pressure water means, for example, a smaller safety zone. Figure 3 compares the typical safety zone around a heat exchanger for a low-pressure water application with the larger safety zone required for high-pressure applications.

High-pressure water cleaning of the past would typically employ around 10 000 to 50 000 psi. Low-pressure mechanical cleaning uses a minimum of 300 psi and a maximum of 600 psi, and requires significantly smaller crew sizes, with reduced risk of accident, injury and component damage.

An important environmental benefit of using a low-pressure method for condenser tube cleaning is water conservation. Typical low-pressure water mechanical cleaning of 5000 tubes will require approximately 8750 gallons of water versus 193 500 gallons for high-pressure water cleaning of the same size unit. Less water use means less to clean up or to reclaim in the post-cleaning phase.

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 condenser tubes. For most plants, time really is money. Because innovative low-pressure mechanical cleaning requires far less unit downtime, it is also the cleaning method that is economically most advantageous for industry. The duration of the cleaning process can be reduced by 70% when using low-pressure water methods.

One such technique is the TruFit low-pressure mechanical tube cleaning system. With this method, mechanical cleaners are propelled through the condenser or heat exchanger tube at 20 feet cleaned per second. Figure 4 compares the typical job duration for low-pressure water versus high-pressure water tube cleaning.

The proof is in the performance. Once a condenser is mechanically cleaned, the plant immediately recovers lost production capacity as tubes are returned to as-new condition. Tubes are cleaner and will require less frequent maintenance. The reduced corrosion rates after mechanical cleaning mean longer component life, more efficient heat transfer and significantly improved process economics.

As already noted, high-pressure water cleaning has been the most common method for cleaning condensers in a variety of industrial settings, but there are significant compromises 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 because water alone is not the best cleaning agent, and the environmental impact of using thousands of gallons of water to clean a condenser unit is attracting increased scrutiny. In drought-stricken parts of the world, where industry and agriculture are bound by strict water usage restrictions that can come with penalties, with the water usage requirements of high-pressure water cleaning making this cleaning approach unrealistic and unusable.

Low-pressure mechnical systems have a much smaller footprint than high-pressure water cleaning methods because cleaning components are smaller and more specialised. Fewer technicians are needed, which means less unit congestion, and this confers a reduced safety risk for the labour force and the equipment being cleaned.

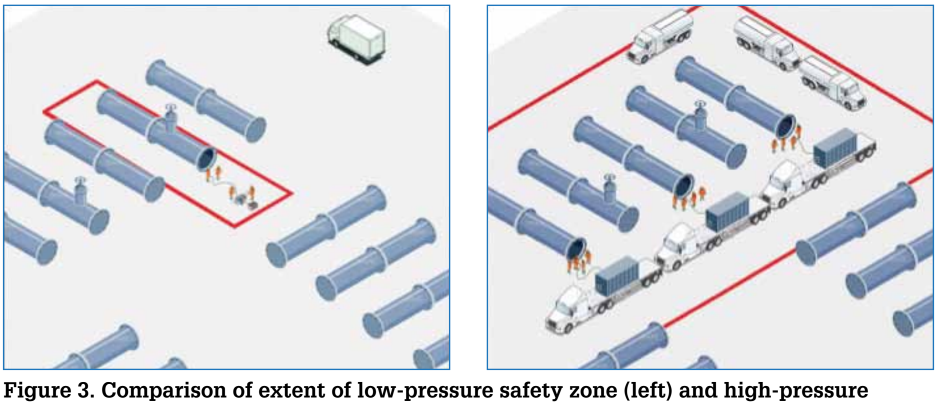
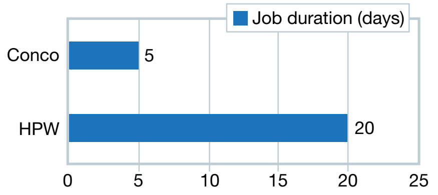


Figure 3. Comparison of extent of low-pressure safety zone (left) and high-pressure safety zone (right)

Figure 4. Job duration comparison. Conco (low-pressure mechanical) vs HPW (high-pressure water blasting)



The environmental impact of low-pressure water use is much less than that of other methods. As already noted, low-pressure mechanical cleaning uses much less water than traditional high-pressure blasting methods, and that equates to reduced exposure to contaminated waste water for personnel and nearby aquifers.

Also, low-pressure cleaning systems such as TruFit mechanical tube cleaners often achieve better cleaning than high-pressure water cleaning methods. Low-pressure mechanical methods are effective at cleaning the most tenacious forms of fouling, such as particulate and biological fouling and calcium carbonate. Condenser tubes cleaned with low-pressure mechanical techniques 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.

Real-world comparison

A real-world comparison of low-pressure mechanical tube cleaning versus high-pressure water cleaning of 21 heat exchangers, found that the high-pressure water method, using 20 000 psi, generated 48 000 gallons of waste water, while the low-pressure mechanical method, at 500 psi, generated only 5000 gallons of waste water.

Why the large disparity in water usage, despite the superior cleaning results achieved with the low-pressure method? This, in part, is explained by the fact that in the case of low-pressure mechanical cleaning, water is pumped for only the three seconds or so it takes the mechanical cleaner to be propelled through the tube. The water flow is then stopped. In contrast, for high-pressure water cleaning, water is pumped for over 70% of the time the system is operating, leading to the dramatic difference in water use.

The photographs on this page show examples of Conco tube cleaning projects. Upper photo: small condenser, big deposits. Lower photo: low-pressure mechanical tube cleaning underway