The Practice of Tube Coating to Extend Equipment Life and Enhance Production Output

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Everyone in the industry understands that the maintenance of heat exchangers is truly mission-critical to ensuring operational efficiency and optimal output. In power plants and petrochemical refineries, without the proper maintenance of heat transfer equipment, such as large-scale condensers or heat exchangers comprised of lengthy, small-diameter tube bundles, operations are brought to a standstill in costly shutdowns for unexpected repairs and unplanned downtime for equipment cleaning and treatment. If expected production exceeds a certain threshold, many plant managers opt to simply replace the equipment entirely every few years to guarantee that production outputs remain on target and to curtail further unanticipated maintenance bottlenecks.

Not all plant operators can justify the capital investment of constantly replacing or retubing their heat exchangers every few years, however. In fact, even the largest refiners and producers look for smart ways to economize on routine operational expenses. There is a viable alternative to the costly replacement and retubing of heat transfer equipment. It is not particularly high-tech or complicated, though it does require a certain degree of knowledge and expertise.

Relief comes in the form of polymer-based coatings applied to the inner or outer diameter of the tubular bundles in this type of equipment. Coating the metal of the tubes dramatically inhibits corrosion and leakage due to water fouling or other bacterial contaminants. With just a single application, tubes remain corrosion-free and operational for the potential life span of the equipment—a significantly longer period than can be expected for equipment using uncoated, or bare, tubes. Finally, coating the tubular systems costs less than a quarter of the price of retubing a condenser, by most estimates.

Coatings Enhance Operational Efficiency

One Gulf Coast refinery tracked its heat exchanger costs over a 12-year period. Measuring leaks per month at six-month intervals from January 1993 through January 2005, the company saw visible improvement in reduced UCLs (unplanned cleanings), which ranged as high as 17 or more per month until July 2001, when they dropped to fewer than two per month after the coatings were applied.

The number of service years between leaks also dramatically increased during the period, particularly from January 2002 to March 2004 and beyond. The number of years between service maintenance for leaks was trending toward 10 years, according to the data, whereas before coatings, the number of service stoppages as frequent as five or six times per year, or, at best, every six months. Outages per month dropped to a mean of less than five in recent years—from a mean of almost 15 per month during the pre-coatings period.

This represents an improvement of 120 fewer service outages and 72 fewer repairs per year. With the cost of an outage at approximately $5,000 per heat exchanger bundle, that translates to savings in outages of $600,000 per year. With coatings and proper maintenance procedures now in place, this refinery now saves at least $1.4 million per year. The cost of outages and repairs previously exceeded $2 million per year; with coatings, the refinery was able to save this amount going forward. Adding in the likely costs of retubing, which run toward $500,000 (estimated) per incident, it is obvious that the practice of tube coatings saves plant operators millions of dollars in a very short time.

In another part of the same refinery, there were six heat exchangers operating in the catalytic cracker recovery unit in the refrigeration section that also needed attention. Their pipes were suffering severe corrosion and pitting, and two older exchangers were so deteriorated they required complete retubings. The remaining four were only three years old at the time, so the company decided to apply coatings to them, as well as to the two new exchangers it purchased. The coatings prevented further damage and served to decrease fouling from sulfate-reducing bacteria. By coating all six exchangers, this best practice in preventive maintenance helped effectively to reduce further stoppages, repairs, leaks and other inefficiencies. The plant quickly achieved better performance from the equipment upon it with coatings.

With corrosion causing leaks and fouling reducing pressure in all six exchangers, the tube bundles in each were given three coats of polymer after first receiving pre-treatment cleaning with mach-speed grit blasting to ensure their inner surfaces achieved NACE-1 standards for white metal cleaniness. Grit blasting also creates a more permeable environment so the coatings can achieve a better bond to the carbon-steel tubes during application.

In the past, coating inner diameter piping had to be done in special shops and could not be done onsite. That meant each heat exchanger bundle had to be pulled from its shell and shipped to a shop off-site. This often precluded the largest units—like "fixed" shell and tube condensers from being transported at all. Progress in techniques has enabled in-situ applications, right in place at the site.

Additionally, coatings are designed technically to "match" or complement the type of steel of the tubes for best effect. Coatings can consist of polyamides, fluorinated products, phenolics and novolacs, depending on the base material to which they are applied. Coated tubes actually maintain a fairly steady level of heat transfer properties over time, contrary to conventional wisdom.

The results the refinery realized in taking the preventive measure of coatings for their six heat exchangers included improved PPI (pounds per inch) in the heat exchangers, which ran at more than 230 lbs in the older equipment before retubing and coating. Afterwards, the pressure drop remained steady within a range of 190 to 200 lbs. During their years of "bare" pipe service, the four "younger" exchangers experienced an increase in pressure drop by 15 lbs per year. Once the tubes were coated, the pressure performance stabilized.

The plant expects a 10-year coating life, barring some minor tube-sheet touchups during maintenance periods. After a decade, the tube bundles will need to be grit-blasted and recoated, but the life expectancy of the heat-transfer equipment can exceed 20 years, conservatively, and the maintenance required is extremely minimal.

Bottom-Line Benefits

Applying polymer coatings to the ID of heat transfer equipment in plant operations provides added benefits, including increased heat transfer duty, elimination of corrosion, a reduction in micro- and macro-fouling, and improved cleaning cycles. Coatings actually yield perpetual equipment life with recoating. Deploying best practices in the application of coatings, such as correlating expected temperatures and exposures of the tubes to "match" the coating properties, guided by quality assurance (QA) techniques, ensures the best performance over time.

Reduced downtime, slower depreciation on capital assets and equipment, fewer stoppages due to repairs or outages, and better maintenance procedures all contribute to improved operational efficiency, gains in production capacity, and ultimately, higher margins for the business. One small ounce of prevention in tube coating can lead to giant steps in maintenance excellence and asset utilization enhancement.

For more information about best practices, contact www.curranintl.com. Curran International specializes in advising on and applying the correct ID and OD coatings for smaller diameter tubular systems such as those found in the heat transfer equipment operating at petrochemical refineries, in the oilfield and in pipeline recompression stations.

A Brief History of Coatings

Fluids that come in contact with tubular surfaces have always plagued heat-exchanger equipment. Historically, water treatment and periodic cleaning by hydroblasting managed this process, but the results were not always optimal. Now, users are applying polymer coatings to the tubular inner and outer diameters (ID and OD) of the heat-transfer apparatus. Over the years, this practice has evolved and matured into a cost-effective remedy to reduce typical fouling and corrosion problems intrinsic to heat-exchanger equipment. Improvements in materials, surface preparation, application and thermal conductivity, plus owner-operator data collection and analysis, have established tubular coatings as viable heat-transfer equipment (HTE) problem solvers.

The Germans first developed phenolic materials for tube ID coatings in the 1950s. Applied by a fill, drain and rotate method in a specialized shop, it was the industry's best option until the mid-1980s. By that time, companies in Italy began experimenting with air-atomized spray applications of epoxy phenolic developed by their engineers. By coating the tube ID with the epoxy phenolic compound, the Italians achieved excellent results and improved fouling and corrosion resistance to the main condensers, which actually restored the generating units to normal operating capacity.

Today, ID coatings are commonly considered a best practice for extending the performance and lifecycle of a heat-transfer system. It took decades of trial and error in upstream, midstream and downstream applications to find the right solutions for each ID, bare metal, and chemical coating compound to optimize the practice for each and every condition and situation.