Curran international
Tubular Heat Transfer Services.

February, 2022

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- AMPP 2022 Conference + Expo 2022,
  Henry B. Gonzalez Convention Center, March 6 – 10.
  Curran exhibiting, Booth # 2235
- API 2022 Inspection and Mechanical Integrity Summit,
  Henry B. Gonzalez Convention Center, August 9 – 11.
  Curran's Booth TBD.

AMPP™ ANNUAL CONFERENCE + EXPO

API American Petroleum Institute

The New Paradigm
for Heat-Exchanger Fouling

Heat exchanger fouling is a significant cost to refinery and petrochemical manufacturing, resulting in lost production, increased maintenance, poor asset utilization, increased CO2 production.

It has been estimated that heat exchanger fouling has a cost of 0.25% of GDP, which, in the United States, annually equates to $537 billion.

CO2 production related to operational fouling in refining alone is equal to 88,000,000 tons of CO2 per annum. Fouling can cost a single, large manufacturing organization hundreds of millions of dollars per year. Such negative effects have motivated material scientists and heat exchanger researchers to seek solutions in design, tube architecture, and low-surface energy coatings.

A Brief History of Coatings

This short article provides summary of current and evolving coating material solutions that mitigate fouling and significantly increase crude manufacturing process efficiency and utilization. These coating material solutions also have a major impact on greenhouse gas reduction.

For decades, highly-functional epoxy coatings have been used in heat exchangers for the primary purpose of corrosion protection. These coatings were generally thick, applied at 200-300 microns, to provide a barrier to corrosive electrolytes, and chemical attack.

An added benefit of coating was the reduction or total elimination of fouling, increased product throughput, and the elimination of maintenance outages for cleaning and inspection. These coatings offered a verifiable return on investment

However, because heat exchangers operate over a wide range of conditions, the concern of heat-transfer penalties resulting from these thicker films impacted wider market adaptation.

New Coating Materials. New Solutions.

Over the last decade, materials research and understanding has significantly accelerated, and provided many new durable, thin film coating materials. These new coating materials that can operate from -40°C to over 1000°C. These low surface-energy coatings provide fouling release with several types of material properties. These fouling deterrents provided by a coating can be 1) a dielectric barrier to ionic exchange, 2) low surface-energy materials like silicone and fluoropolymers, 3) low polar value, and ultra-smooth surfaces.

These new coating materials range in thickness from sub-micron ("nano") to 50 microns. At these thicknesses, the coatings themselves are thinner than even a light fouling layer. Modeling with thermal design software shows fouling factors well below the fouling factors built into the initial design parameters.

Application methods have also kept pace with the new materials for a range of heat exchanger surfaces; including tube Inner diameter, outer diameter, plate and frame, spiral, finned, Twisted Tube®, and other geometrically enhanced surfaces.

Anti-Foul Applications Ready for Deployment

Several material groups that have been successfully developed, tested, and deployed. These groups have had huge impacts on reduction of exchanger fouling. These applications have averaged a 10-times return on the application investment. Such advanced materials provide superior adhesion performance, and yield a low surface-energy finish, which improves operational cost efficiency and reduces CO2 emissions.

Epoxies are a well-established polymer for immersion service and have been used for over 30 years in heat exchanger coating. General specifications for carbon steel application, where corrosion protection is the main goal, is 200 microns, (.008"). In less reactive alloys, such as duplex SS, 304, 316, and copper based, the specification is reduced to 50 microns or less.

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In these services, mainly for cooling water or process water, a service life of 10-20 years is normal and no reduction in service life is experienced with the thinner films. Advanced formulations have been tested to reduce, eliminate high-temperature oxidation. In two separate autoclave tests, one at 185c in 150,000 PPM NaCl, CaCl for 60 days and one at 95C in 250,000 PPM for 180 days, no fouling-attachment was observed. Field deployment confirms the suitability for high chloride and other high-fouling services, and functional in-service temperatures up to 200C.

Siliconized and Fluoropolymer infused epoxies – Well established and used for heat exchanger cooling water for more than 30 years. Applied at 50 to 200 microns, for services to 200°C, a service life of 10-20 years is expected. However, as service temperatures are raised above 70c, a slow oxidation of the surface can occur that raises the surface energy above 80 mN, and surface roughness from 2 micron Ra to 25+ Ra, providing nucleation sites for fouling. Experimental work and testing of both fluorinated and silicone modification of these epoxies shows these coatings will maintain the low surface-energy and oxidation-protection and, thus, provide a durable, long-term, antifouling layer.

Sol gel – A silicone coating; sol-gel provides very low surface-energy (20 mN), low surface- roughness, (0.5 micron Ra), and elastomeric anti abrasion properties in a very thin film application, (5-25 microns). Such applications have performed with great success in plate and frame exchangers, as well as in crude, and crude/water solutions. In these applications, sol gel coatings have increased runtimes between cleanings from months to years. Applications to shell and tube exchanger have been developed and deployed with equal success. Sol gel coatings operate effectively between -100°C to 300°C and can be applied over any metallurgy.

Fluoropolymer – Thin films applications applied for “release” and antifriction did not provide durability in immersion. For chemical resistance, thick films of 750 to 1000 microns are used to overcome porosity in immersion. In the early 2000s, a thin-film coating, applied at 75 microns, was developed. This coating provided great adhesion, a corrosion barrier, and low surface- energy release properties. Refinery clients who upgraded to these coatings have successfully used these coatings in high-fouling service water (crude mixed with water), and other highly corrosive services. Many exchangers previously needing frequent cleaning or replacement, now operate for very extended times without tube leaks or cleaning events. These coatings are effective at service temperatures up to 250C,(500F), and in caustic, acidic and process water services.

Floating head tube bundle, full length tube IDs coated with StreaMax™, a fluoropolymer with Teflon.

Ceramics – While the term “ceramic” is used loosely, there are several coatings based on pre-ceramic polymers that offer low surface-energy, excellent adhesion, superior chemical resistance, and high thermal stability- up to 400C in an amorphous state. Ceramic coatings, when sintered at 850C, become a true multifunctional crystalline ceramic that can be utilized in furnace and higher temperature corrosive and fouling applications. These coatings are primarily utilized at 400C and below in their amorphous state. Ceramics are generally applied in the 10–25-micron thickness range and can be cold or heat cured. Service temperatures, 400C, amorphous, 1000C, crystalline.

Sintered Ceramics – Cured in a high temperature vacuum furnace, these coatings have been specifically developed for anti-coking services in ethylene steam cracking furnaces. Initial deployments have now been in-service for over three years and have demonstrated significant runtimes of three-times between decoking cycles. Service temperature, 900C, extending runtime and reduction of metal fatigue. The benefits of sintered ceramics include, operation efficiency, CO2 reduction, extended runtime, and the reduction of metal fatigue.

Nano Metal Oxides – Metal oxides have been used as thermal barrier coatings for many years. Metal oxides can also have low surface-energy properties. Testing has demonstrated these materials can provide a stable anti-coking surface in high temperature furnaces, towers and heat exchangers. Service temperature, 1000°C; applied at sub-micron (nano) thickness, high temperature stability.

In Summary

Years of material and application research, supported by field and manufacturing trials, have resulted in a new era of coating applications to solve high temperature heat exchanger fouling.

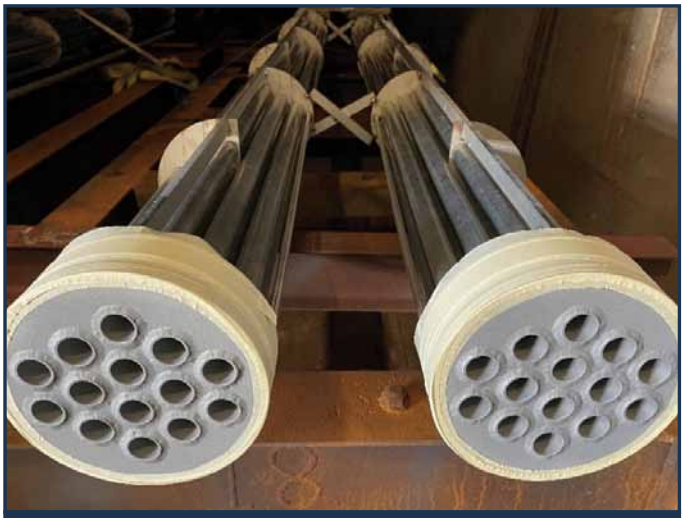
Client observed and anecdotal feedback shows these applications successfully mitigate fouling or corrosion and contribute to performance improvements:

- CO2 reduction
- Maintained exchanger duty
- Better Log Mean Temperature Difference (LMTD)
- Extended runtimes or total elimination of cleaning events
- Significant flowrate improvements through the exchanger
- Process efficiencies with a ten-times return on investment

Coating applications enable heat exchangers to perform as designed and achieve maximum performance, with minimal or no cleaning-periods.

Curran Knows Coatings

Contact Curran International for more information about advanced coatings and applications for all types of heat exchanger designs and service conditions. Visit our website https://www.curranintl.com/foul-release-exchanger-coatings, or email Edward Curran, ecurran@curranintl.com.



“Hairpin” type exchanger coated with Curramix 3500; a “ceramic” coating applied to full length tube IDs at less than 50 microns.

Alternative Repair Solutions

for Air Coolers and Tubular Heat Exchangers.

Cost-effective Exchanger Tube Repairs – On Time!

We are all aware of the financial cost and dangers associated with tube failures in critical process heat exchangers. These failures lead to costly unplanned outages, drive-up unscheduled turnaround costs, cause process delays and lower profitability.

Tackling the Issues.

Using an array of alloys, Curran provides unique tube repair options that allow clients to upgrade the metallurgy of an existing unit without the high cost of a complete unit replacement.

To help maintain your unit's optimal functionality, tube liners and ferrules are the right choice for repair instead of tube plugging. Curran installs ferrules or full-length liners in-situ, and during short maintenance outages. The installation inhibits the factors that create failures within the tube walls, such as local corrosion or accelerated erosion. Such failures attack the parent tube, causing tube-to-tube-sheet joint failures, enhanced corrosion rates throughout the parent tube, and stress cracking due to process velocity and turbulence.

Curran's Unique Process

Curran's unique process of installing and hydraulically expanding tube-end ferrules or sleeves, and full-length alloy tube liners can be seen here in the link to the animation. https://www.curranintl.com/.

Utilizing Curran's hydraulic expansion process of tube inserts ensures uniform expansion, resulting in long-term tube restoration. Hydraulically expanding the tube liner/inserts 6500 – 7500 PSI insures a 360-degree full-contact with the parent tube down the length of the liner. This contact improves wear resistance, so the tube-end and its sealing integrity within the tube sheet is maintained. The installed ferrule/liner serves as a wear barrier to mitigate the damage done to the parent tube due to process factors attacking the tube I.D., all the while regaining tube wall thickness and corrosion protection.

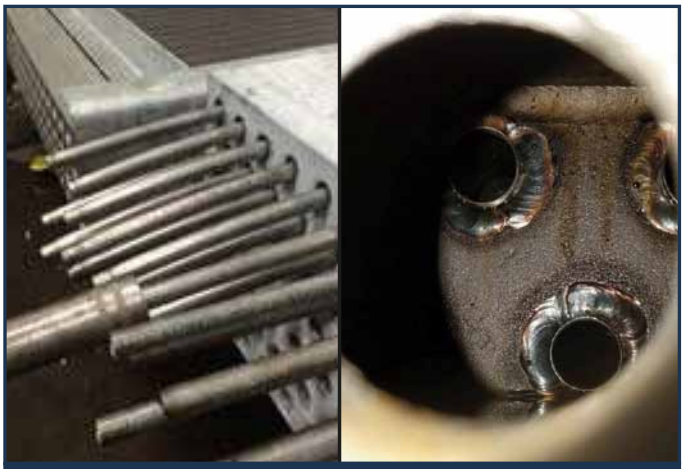
The benefits of installing a corrosion resistant alloy for use as a full-length liner, or tube-end ferrule, protects and improves the reliability of the parent tube to combat specific corrosion mechanisms that lead to failure. Of course, eliminating unexpected failures between scheduled turnarounds and extending service life beyond routine outages boosts profitability.

A Full-Service Contactor- Worldwide

As a full-service contractor, Curran's ability to provide all-inclusive turnkey solutions places Curran International at the forefront of maintenance excellence. Curran is the company-of-choice, valued for turnarounds, outages, or emergency projects of any size. Curran crews work around the clock and around the world to meet your needs.

Please visit https://www.curranintl.com/hydraulically-expanded-alloy-liners to learn more about Curran capabilities, or contact Sales at 281.339.9993.

Inlet-end damage at tube-end, Curran used an alloy liner to add a corrosion barrier.



Images of full-length liners being hydraulically expanded, close up image of liner tubes trimmed to existing tube projection inside cooler header box.

Nano-Thin Release Coating

for Small Complex Components

Adaptability. Agility. Persistence.

Curran International is excited to announce its partnership with DropWise Technologies Corporation, a developer of a coating application using an initiated Chemical Vapor Deposition (iCVD) technique.

The combined effort of the two companies provides increased capabilities to apply release coatings to the most complex components- improving their resistance to water-scale and deposit-fouling, and reducing the need for routine maintenance.

Thin-Coating Complex Structures

DropWise Technologies, a startup based on research at two MIT labs, has combined advanced coating materials and a novel process for coating deposition – iCVD. The result is ultra-thin application of polymers with significant hydrophobic properties that can now be applied onto surfaces of complex components subject to water-service scaling and deposits.

Curran has successfully performed trial applications at its Houston area shop, where DropWise iCVD equipment is installed. The equipment grafts ultra-thin polymers to metal surfaces under a vacuum by flowing gases across hot filaments, while maintaining the metal surfaces at room temperature.

Curran has used this technique to apply a low surface-energy polymer to a complex-geometry stainless steel water filters using the iCVD technology developed by DropWise. The nano-thin polymer coating is deposited conformally across all surfaces of the complex geometry of the filters.

Successful Testing

A demonstration project, coating stainless steel water filters for an appliance OEM, demonstrated exponential runtime without cleaning, and greatly reduced routine maintenance. Testing at this major appliance OEM showed duty equal to one-year of 150 cycles, without water scale or fouling. The OEM has conducted extensive testing to represent a 10-year run of a Curran-coated filter basket.

DropWise Technologies Corporation iCVD coating process

In the process, an advanced polymer resin is vaporized and in a vacuum is 100% conformally applied on all surfaces of the filter basket. Once chemical vapor deposition begins, the process yields an ultra-thin film deposition at less than 5 microns onto all part-surfaces in the vacuum chamber. The stainless-steel filter that was coated has mesh of 0.5 mm x 0.5 mm. Testing on filters was deemed extremely successful. Scanning electron microscope images taken after the test show no attachment of water particulate at openings.

The 100% conformal coating application of advanced thin film resins serves to protect complex parts and components used in electronics, instrumentation, aerospace, medical and engineering industries. A range of resins can be used for this application technology, chemical stability, thermal endurance, and high tensile strength are key attributes. Some of these advanced resins are available for medical and food grade formulations.

A Wide Range of Uses

DropWise iCVD technology is extremely scalable and can be used in a wide range of industries, tooling, flow path components, wear components, and instrumentation.

Curran International is looking forward to commercial inquiries for anti-fouling application using DropWise Technologies. Whether you are a manufacturer designing a new device, or an end-user impacted by fouling or corrosion maintenance issues, Curran is eager to work with you to help engineer an effective solution, contact Edward Curran at ecurran@curranintl.com, or Sales at 281.339.9993.