Corrosion prevention in the manufacturing environment is a significant issue given the harsh conditions under which many production processes are performed. For the same reason, it is often very difficult to effectively achieve. In the food processing industry, there are added challenges; corrosion prevention in many instances must be accomplished using materials that meet strict requirements for direct or indirect food contact (e.g., in the US 21 CFR 175.300 for food contact use). Many types of coatings—both inorganic and organic—are used for corrosion prevention of the processing equipment and floors, walls, and ceilings in processing plants. Some types of food and beverage packaging (e.g., metal cans) also require coatings for protection against corrosion.

**FOOD PROCESSING INDUSTRY CHALLENGES**

The food processing industry is one of the largest manufacturing sectors in the United States. The food processing environment is also highly corrosive due to the extensive requirements for cleaning and sanitation and the corrosive nature of many food products. According to NACE International, the world’s leading corrosion control organization, nearly $2.1 billion is spent annually on corrosion-related costs by the industry. Corrosion in food manufacturing environments is a significant issue because it can lead to equipment failures and thus costly downtime, and it has the potential to impact product safety and quality. “The food and beverage industry is highly regulated across the global supply chain, by the FDA in the United States and under global food safety initiatives (GFSI) internationally, to harmonize food standards—and for good reason: the food supply chain knows no country borders,” says Julie Vaughan, vice president of marketing and business development with Emerald Performance Materials.

Indeed, concerns about safety due to contamination, taste alteration, and equipment malfunction are added challenges that other sectors, such as the construction industry, do not have to contend with, according to Ameen Baghdachi, professor of Polymers and Coatings and graduate program coordinator at Eastern Michigan University. “Unlike heavy industries such as oil and gas, transportation, etc., people and animals come in contact with food products and, in addition, multiple products with a wide range of pH, viscosity, and abrasion properties are typically processed in any given food plant. Furthermore, unlike in other sectors, each individual consumer is a watch-dog for this industry,” he explains.

One of the leading causes of corrosion in food processing facilities is the extensive use of high-pressure water and steam, often in combination with various corrosive agents (alkaline, acidic, oxidizing, and reducing chemicals), for cleaning purposes. Water is widely used for food processing. In addition, many foods are mildly (pH 6-7) carbonated sweet drinks, beer, soups, and canned meats) to strongly (pH 3-5: citric fruit juices, jams, sauces, dressings, and pickled vegetables) corrosive and, or are processed using concentrated organic and inorganic chemicals (acids, salts). The enzymes in foods can also lead to corrosion, as can microbial contamination of surfaces. Unlike in many other industries, however, the use of powerful corrosion inhibitors is heavily restricted and, in many cases, not permitted in food processing plants for safety and health reasons, according to Baghdachi.

**EFFECTIVE CORROSION PREVENTION**

While careful facility design (smooth, curved, bonded/solid, easy-to-clean, and drain surfaces) and the selection of appropriate coatings are important, proper cleaning and sanitation regimes may also be crucial. Many food processors rely on harsher cleaning solutions with high pH, compared to normal or mild cleaning solutions that are used in hard surface applications, and this can often accelerate the corrosion process.
Coatings for Corrosion Prevention in Food Processing Facilities

By Cynthia Challenger, CoatingsTech Contributing Writer

Corrosion prevention in the manufacturing environment is a significant issue given the harsh conditions under which many production processes are performed. For the same reason, it is often very difficult to effectively achieve. In the food processing industry, there are added challenges: corrosion prevention in many instances must be accomplished using materials that meet strict requirements for direct or indirect food contact (e.g., in the US 21 CFR 175.300 for food contact use). Many types of coatings—both inorganic and organic—are used for corrosion prevention of the processing equipment and floors, walls, and ceilings in processing plants. Some types of food and beverage packaging (e.g., metal cans) also require coatings for protection against corrosion.

FOOD PROCESSING INDUSTRY CHALLENGES

The food processing industry is one of the largest manufacturing sectors in the United States. The food processing environment is also highly corrosive due to the extensive requirements for cleaning and sanitation and the corrosive nature of many food products. According to NACE International, the world’s leading corrosion control organization, nearly $1.2 billion is spent annually on corrosion-related costs by the industry. Corrosion in food manufacturing environments is a significant issue because it can lead to equipment failures and thus costly downtime, and it has the potential to impact product safety and quality. "The food and beverage industry is highly regulated across the global supply chain, by the FDA in the United States and under global food safety initiatives (GFSI) internationally, to harmonize food standards—and for good reason: the food supply chain knows no country borders," says Julie Vaughn, vice president of marketing and business development with Emerald Performance Materials.

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Ceramic-resistant materials (largely stainless steel for processing equipment and concrete for floors and walls) are the foundation of an effective corrosion prevention program, there are many instances where even highly corrosion-resistant substrates need additional barrier protection to extend their service lifetimes. Coatings serve several purposes the food and beverage industry and must stand up to the sanitation chemicals and procedures used for processes that adhere to the GMPs (Good Manufacturing Practices) that keep the food supply safe. In addition, regulations governing the food and beverage industry follow the product through all stages of production, meaning that, in addition to the stringent rules for the equipment, packaging, surfaces, and products that come into direct contact with food, indirect food contact materials also play a significant role in food safety, observers Vaughn. For steel structures and equipment, galvanizing with metallic zinc is the most common coating method for the corrosion prevention in the food processing industry. However, in some cases, an additional topcoat, typically an organic or inorganic hybrid system, is applied for additional protection. In some applications, three-coat systems are employed. Polyurethanes and fluoropolymers are typically preferred for topcoats over metal substrates, while 100% solids, self-leveling epoxy systems are typically used on concrete surfaces, although polyurethane topcoats may be applied to the epoxy systems for aesthetic purposes. Where fast return-to-service in concrete coating applications is imperative, a modified bisphenol A epoxy resin can be used in combination with phenylalkylamines, according to Hitesh Soni, product manager for specialty epoxy materials at Emerald. “This approach has been shown to achieve a 50% faster return-to-service at ambient conditions and can also effectively cure at near-freezing temperatures,” Soni says. Food-grade polyurea coatings have been developed that can be used to rehabilitate the walls and ceilings in food processing plants. The process involves reshaping of surfaces so that only smooth, curved lines remain and eliminating areas where water, dirt, grime, and pathogens can accumulate.

Regardless of the type of system and substrate, these coatings act as physical barriers to moisture and chemicals. In most cases, proper surface preparation is crucial and has a direct impact on coating performance. Advances in coating technology have, however, led to the development of protective coatings that are more forgiving with respect to the surface condition. One interesting technology used in corrosion under insulation applications in the food and beverage industry is a reactive gel corrosion treatment. This mineralization technology involves the formation of a thin 20-50 Angstroms glass-like mineral film via the reaction of components in the reactive gel with the steel surface. The film has excellent adhesion to the steel and is hydrophobic, and therefore acts as an effective barrier. If water does penetrate into the film, it is buffered to a high pH. In addition, the reactive gel is tolerant of poor surfaces and can be applied to both new steel and pre-coated substrates with minimal surface preparation.

New and existing food plants often require protective coatings that will create smooth and seamless vertical and horizontal concrete surfaces to help safeguard substrates from contaminants and resist abrasion, chipping, and corrosive factors such as moisture and chemicals, according to Joe Schmit, sales director for StratusShield with Tnemec Company Inc. These coatings are also designed to facilitate efficient cleaning, sanitation, and workplace safety, according to Schmit. “The ultimate goal of any reservoir floor or wall system is to limit out-of-service time during and after application. Downtime must be limited during the construction of the system,” he explains. While most floor and wall coatings do not come in direct contact with food and are classified as “incidental contact areas,” and particularly for retrofit situations, coatings must be low VOC, low odor, and 100% solids so they can be applied in the proximity of people and food. “Concrete floors in food processing plants must resist degradation from chemicals used in frequent cleaning and sanitation, which are much more stringently applied in food processing environment than other process industries,” states Soni. In addition to a quick turnaround time and low VOCs, low odor and surface tolerance are other important properties for floor and wall coatings used in the food processing industry for both contamination and corrosion prevention. “In order to maintain high production rates, plant owners sometimes specify minimal surface preparation. In addition, personnel often remain in the area being coated, so coatings must be able to adhere to surfaces without being hazardous or odorous,” Schmit observes. For new concrete floors, he adds that moisture vapor transmission (MVT) is another factor that must be considered when selecting coatings for use in food processing plants. In the past decade, the construction industry trend has been to fast-track projects, with surfaces coated and cured quickly, even before the concrete surface has met the typical 28-day curing time required of most concrete. For this application, the coating must meet all of the above criteria plus be resistant to MVT and the associated high alkalinity,” says Schmit.

NEW TECHNOLOGIES

A number of technologies are being explored to improve the corrosion protection properties of coatings used in many different industries. Examples include the encapsulation of corrosion inhibitors in powdery self-healing coatings, the use of potentiostatic agents, the creation of sprayable hydrophobic surfaces through the addition of additives, and for the formulation of hybrid organic/inorganic coatings. One example of the latter technology has been developed by Professor Mark D. Soscek at the University of Akron. His modified ceramics are prepared by reacting tetraethyl orthosilicate (TEOS) oligomers with alkyl silane modified isocyanurates. The isocyanurates provide connectivity between the inorganic and organic phases, while oligomerization of TEOS inhibits its volatility. The resultant coatings, which are sprayed as homogeneous solutions, in a one-coat application, self-stratify via simultaneous crosslinking to form multi-coat film structures without any interlayer boundaries, according to Soscek. In addition to reducing the cost of coating application (one-coat system), these ceramics have improved adhesion, mechanical, and finishing properties (e.g., mar resistance for longer service lifetimes. Furthermore, the acid priming ceramics provide the corrosion protection to metal substrates without the need to use environmentally hazardous chromate treatments,” Soscek notes.

Other technologies under development include 100% acrylic coatings, sol-gel materials and coating application to allow a quick return-to-service. In addition, floor and wall coatings in the food processing industry should last as long as possible to prevent excessive maintenance that could cause downtime or any kind of “shutdown,” he explains. While most floor and wall coatings do not come in direct contact with food and are classified as “incidental contact areas,” and particularly for retrofit situations, coatings must be low VOC, low odor, and 100% solids so they can be applied in the proximity of people and food. “Concrete floors in food processing plants must
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Corrosion Prevention

NEW TECHNOLOGIES

A number of technologies are being explored to improve the corrosion protection properties of coatings used in many different industries. Examples include the development of corrosion inhibitors to provide self-healing coatings, the use of artificial intelligence, the creation of advanced polymer materials, and the development of new coating systems.

One interesting technology is the use of corrosion inhibitors to provide self-healing coatings for structures. The process involves the addition of a material that can automatically repair damage to the coating when it is damaged. This technology is still in its early stages, but it shows promise for reducing maintenance costs and improving the durability of coatings.

Another area of research is the development of coatings that can adapt to changing environmental conditions. These coatings are designed to change their properties in response to changes in the environment, such as temperature or humidity. This technology could be particularly useful in industries where coatings are exposed to extreme conditions, such as the oil and gas industry or the aerospace industry.

Overall, the development of new coating technologies is an important area of research that has the potential to significantly improve the performance and durability of coatings used in a wide range of industries.