A Jack of All Trades

Myles Johnson, ClockSpring|NRI, USA, considers the various applications of composites for piping systems at risk of corrosion.

Composites are a versatile and robust solution for many problems facing piping systems across the upstream oil and gas industry, including on offshore platforms. The flexibility of composites makes them adaptable to a range of situations.

A composite is made up of reinforcing fibres held together by a thermoset polymer resin. The fibres provide strength and stiffness to the repair while the resin protects the fibres and holds the repair together. Various combinations of fibre and resin can be used to give the composite

different properties so that it can address multiple issues, such as providing mechanical protection for an existing coating, preventing external corrosion, or repairing pipe that has already been damaged from external corrosion or other serious defects.

Prevention

In the case of external corrosion, the adhesive primer component of the composite repair system not only helps the composite adhere to the pipe, but it also acts as a barrier coating to prevent moisture ingress on the pipe. While all composite repairs, when properly performed, prevent further corrosion and protect the pipe, some systems are specifically designed to withstand harsh conditions and be used as a preventative measure. Areas that may require extra corrosion prevention include pipes in heavy salted areas such as offshore locations.

Figure 1. *It is common for pipelines to experience abrasion and corrosion at support and hanger locations.*

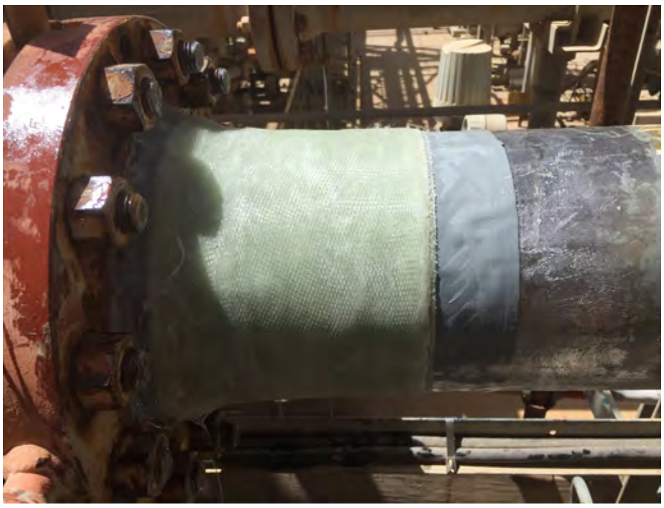

Figure 2. *The composite system creates a sacrificial wear plate, preventing both crevice and galvanic corrosion, accommodating the weight of the pipe and preventing abrasion from pipe movement.*

Case study: minor external corrosion

After the protective coating on a 4 in. pipe section failed, the pipe experienced minor external corrosion. The external corrosion was within the corrosion allowance, thus not requiring a structural repair. However, a composite repair was installed to prevent future coating failure and external corrosion in this congested area, while offering greater mechanical protection to the pipe. The complicated geometry of the pipe section made it ideal for a low width composite repair that can easily conform. Prior to installation, the pipe was cleaned with all rust and scale removed. Once installed, the composite repair was top-coated to protect from UV degradation.

Crevice corrosion

Another dangerous area for potential corrosion is any location where the pipe is in contact with something else. Composites built for energy absorption and stress redistribution can be ideal for impact protection and vibration dampening. Additionally, pipes resting on supports are susceptible to crevice corrosion due to axial movements and vibrations that will wear down the coating over time, resulting in metal-to-metal contact with the support. This results in the localised attack of metal at the support. One of ClockSpring|NRI's technologies, the Pipe Sock™ system, is designed to prevent this situation from occurring. The system consists of a pre-cured fibreglass wear pad and an elastomeric adhesive. In addition to having high adhesive properties, the elastomeric polymer demonstrates a greater toughness and flexibility, which allows it to survive conditions that would otherwise cause cracking and failures for similar epoxy-based wear pads. Some of the conditions that should be considered when dealing with crevice corrosion include thermal expansion, vibration, axial loads and types of pipe support.

Case study: collar clamp repair

A 6 in. pipe was experiencing general external corrosion due to contact with a pipe support and a collar clamp (Figure 1). In addition to restoring lost strength, a composite wrap was utilised to prevent further metal-to-metal contact with the pipe support and minimise movement and corrosion in the collar clamp. To wrap over the collar clamp, the empty space around the bolts needed to be filled in to remove air-pockets and voids underneath the composite repair. To achieve this, a thixotropic, non-sagging filler paste was provided that had a consistency similar to peanut butter and is easy to apply in large volumes. After the filler paste was allowed to set, it was wrapped with a composite to provide structural reinforcement to the affected pipe and prevent further metal-to-metal contact (Figure 2). Although rigid fibreglass wear-pads can be used to prevent crevice corrosion, a field applied composite can be applied in unique situations where pre-formed solutions are neither practical nor convenient.

Repair

External corrosion occurs when a pipe coating fails and the pipe is exposed to moisture. This failure will cause the pipe wall to thin, which reduces its pressure-carrying capabilities. When the damage is severe enough, simply recoating the pipe will not be adequate and it will require structural reinforcement to restore the pressure-carrying capabilities. Composite repairs can be used to restore this lost strength and allow the pipe to operate safely. The design of composite repairs for such structural reinforcement is guided by the equations and methodology in ASME PCC-2 and ISO 24817.

The operational conditions of the pipe are important factors in deciding what type of composite to use. Temperature, environmental and chemical resistance, conformance to odd geometry and pipe location must all be considered when determining which system will be effective. For example, high operational and design temperatures will require a thermally-resistant resin with a high glass transition temperature (also known as Tg). Tg is the temperature range at which the resin will transform from a hard and glassy material to a soft and rubbery one, whereupon it will be more susceptible to creep and may be unable to handle the required stress loading.

Another operational difficulty is repairing pipes located in splash zones or underwater. Most epoxies are hydrophilic, which means that they will not cure properly in the presence of high-moisture content. This is a significant problem for offshore facilities where many of the damaged pipes are in a splash zone or underwater. Instead, a hydrophobic epoxy should be used because its cure is not adversely affected by the presence of moisture, which allows it to be used in wet environments.

Case study: splash zone repair

Three crude oil risers located in Southeast Asia were experiencing external corrosion and needed reinforcement. The existing neoprene coating on the risers was damaged and severe corrosion was found underneath. These risers were repaired by using the company's A+ Wrap™ composite repair system along with the SplashBond™ primer. The polyurethane system within the A+ Wrap system utilises moisture to start the polymerisation reaction and can function in wet environments (Figure 3). The primer is a hydrophobic adhesive that will displace the water on the surface of the pipe and cure in wet conditions. The repair was successful in restoring structural integrity to the corroded risers (Figure 4).

Figure 3. *The polyurethane system within the A+ Wrap system utilises moisture to start the polymerisation reaction and can function in wet environments.*

Figure 4. *Three crude oil risers located in Southeast Asia were experiencing external corrosion and were repaired by utilising the SplashBond™ primer.*

Additional defect uses

Composites can also be used for other defects including, but not limited to, internal corrosion, dents, wrinkle bends and girth weld reinforcements.

Leak repairs are the second most common type of defect behind general external corrosion, and they provide their own set of challenges. ASME PCC-2 refers to non-leaking structural reinforcement defects as Type A defects and leaking defects as Type B defects. Instead of only restoring the lost strength to the pipe – as in Type A defects – solutions addressing Type B defects also need to contain the contents of the pipe. The composite can fail in three ways:

- The composite can fail at the bondline and the leak will escape the sides.
- The leak can work its way through the composite thickness.
- The composite can degrade due to chemical attack.

All these factors need to be accounted for in the design of an effective composite system.

Case study: leaking repair on discharge line

A 14 in. firewater overboard discharge line was being corroded due to the aggressive sea water environment. Over time, this non-pressurised line developed two large holes causing potential discharge to spill onto the deck. In order to install a composite repair on the line, a stop gap must be used to plug the hole and keep the contents inside the pipe during installation. Clamps and wooden dowels are two commonly used stop gaps, but this repair utilised a quick set putty filler material to plug the hole. The putty has a consistency similar to clay and sets within 5 –10 minutes, forming a seal on the pipe. A composite repair was then applied over the defect to prevent further leaks and external corrosion.

Protection

Liquid epoxy coatings and fusion-bonded epoxies are two popular anti-corrosion coatings used in the piping industry. Both coatings offer dependable protection from external corrosion due to their good electrical resistance, low water permeability and favourable adhesion strength, but they do not offer much support when it comes to protecting the pipe from mechanical damage. This deficiency means that the coatings are susceptible to being damaged by external forces, which can lead to disbondment and external corrosion of the pipe system. Composites not only perform well as a barrier coating to prevent external corrosion, but the reinforcing fibres also provide strength to the repair, which makes it more resistant to mechanical damage and enhances long-term performance.

The most prevalent use for composites in terms of protection is to absorb external abrasion, thereby protecting the pipe during instances of operation or installation, such as high-directional drilling. The use of proper fabric combined with hardened resin can lead to strong sacrificial layers that can prevent the pipe from incurring any major damage. For pipes exposed to continuous erosion due to sand or other debris, a composite wrap will protect the pipe and coating and additional layers can easily be added if necessary.

Case study: ice protection

Risers on offshore platforms located in the cold waters of Alaska, US, are susceptible to aggressive mechanical damage from ice sheets that flow into the pipes. Using a rubbery under-wrap and a stiffer outer-wrap, the A+ Wrap system composites have been successful in distributing and absorbing the energy from the ice sheets, which results in no permanent damage to the underlying pipe or coating. Large loads and smaller strike impacts can be shielded against by using the appropriate system. Even if a particularly devastating impact damages the composite, a replacement can be made without interfering with the underlying pipeline operations at a relatively low cost.

Conclusion

Composites can be an effective and versatile rehabilitation solution for pipes in the oil and gas industry. By using various combinations of fibre and resin, composites can be tailored to perform in multiple operational and defect scenarios. Many types of resins can be used to make the composite more resistant to chemicals, abrasion, temperature or wet environments. Different fabric weaves can be used to provide better leak containment, while the fabric itself can be used to provide greater strength and improved resistance to cyclic fatigue or better absorb impact energy. Composites can be used in conjunction with an existing coating to provide more mechanical protection, prevent additional corrosion or to provide a structural reinforcement to repair already damaged pipe that a simple recoat would not address. Whether for prevention, repair or protection, a properly designed and installed composite can be a valuable tool for protecting infrastructure against corrosion for decades.