



Fig. 1. Complete (27 x 23.5 metres) FRP flue gas scrubber with outlet duct in 600MW power plant on the Ohio river.

# Fibre reinforced polymers for corrosion control

**Michael G Stevens looks at the uses of fibre reinforced polymers FRP to control corrosion in industrial applications.**

**F**ibre reinforced polymers (FRP) have been used to solve corrosion problems for more than 50 years in many industries including chemical process, mineral processing, pulp and paper, and coal burning power plants. In many applications, fibre reinforced polymers provide superior performance to other materials of construction. As such they are now becoming the first material considered rather than one of last resort. Numerous case histories will be shown in this paper where these versatile materials have been used successfully in the control of corrosive environments.

In the early 1950s, a chlor-alkaloi manufacturing plant was suffering from serious corrosion problems in its cell heads and headers. The chlorine cells required replacement in less than one year's time. A new type of polyester resin, based on chlorendic anhydride, was developed in answer to this critical need. This chlorinated unsaturated polyester resin was referred to as a chlorendic polyester resin. When this material was used

in combination with glass fibres to make the chlorine cell covers and headers, the equipment lifetime was extended to 5-8 years compared to the original construction materials which required replacement in less than one year. This was the start of the use of fibre reinforced polymers (FRP) in corrosion control. Over the next 50 plus years new materials have been developed for many different applications. It is now easy to choose a resin that will give very good performance in many different applications. Over the years, reinforcement materials have also been improved significantly. Innovations in both fields have resulted in substantially longer, maintenance-free life from FRP equipment. The use of FRP resins in a variety of industries will be discussed herein. This review will give the reader an overview of where FRP materials should be considered. The use of FRP can also be more economical in applications where high nickel alloy steels or even stainless steel is required with a coating or lining. FRP also will generally have lower maintenance requirements as compared to coated steel.

The mineral processing and mining industry uses a variety of strong acids to extract minerals from low grade ores. The principal acid used in mineral processing is sulfuric acid, which is very corrosive to most all metals as well as concrete. If steel is used for the storage tanks or process equipment, a protective coating or lining will also have to be applied. Most of these coated or lined tanks require ongoing maintenance to keep the steel protected.

A better option in these applications is to use FRP equipment made with a resin that is resistant to these strong acids. The most common resin used for these applications is a bisphenol A epoxy vinyl ester resin. Many pieces of equipment can be made using epoxy vinyl ester resins. These applications include but are not limited to electrolytic cells, electro-winning cells, electrostatic precipitators, extractors, ducts, fans, scrubbers, stacks, stack liners, cell covers, grating, railings, storage tanks, settling tanks, pipes, pumps, and cooling towers. There are many case histories available to support the successful use of epoxy vinyl ester resins in such applications. A few of these are shown at the end of this paper.



**Fig. 2. Chimney with two FRP stack liners in operation in North Carolina.**

these acid gases is the wet FGD scrubbing system. Limestone slurry is typically used as the scrubbing medium. This will eliminate about 99 per cent of the sulphur dioxide in the flue gases. The scrubbing environment is highly corrosive to metals but the scrubbers, limestone slurry piping, water piping, duct work, and stack liners can all be made out of properly designed and fabricated FRP. The proper resin needs to be specified to obtain long maintenance-free service. Other areas in the power plant where FRP can be use are mist eliminators, cooling towers, storage tanks, and cable trays. FRP is very cost competitive compared to the high nickel steel alloys that would otherwise have to be used in this corrosive environment. Equipment made from high nickel alloys is at least twice the cost of comparable FRP

equipment. The other option would be to use a coating or an FRP lining on the steel equipment. Although this is a viable alternative, maintenance costs tend to be significantly higher with the coatings and linings.

One of the very first uses of FRP was in a chlor-alkai plant. A chlorinated polyester resin was developed to withstand the corrosive environment of the cell covers and cell headers. Novolac epoxy vinyl esters have also been used in making the cell headers at chlorine plants. Other areas where FRP components can be used successfully are piping, storage tanks, grating and hand rails. The use of FRP has also expanded into many other chemical process plants. Some areas ideal for FRP are where mineral acids are present or where chlorides are present. Chlorides in water such as salt water and brine are very aggressive toward stainless steel. These are ideal applications for FRP because equipment manufactured from corrosion grade isophthalic polyester resin or epoxy vinyl ester resins are almost inert to salt water at temperatures up to 180°F. These resins have been used for FRP in piping and cooling towers especially when sea water is used. Other applications include tanks, reactors, scrubbers, piping, gratings and duct work. A few examples are shown below.

Wastewater treatment facilities have many applications where FRP is currently being employed. Sodium hypochlorite is the material of choice for treating waste water currently. The



**Fig. 3. FRP Stack liners.**

The bleaching process used in the manufacture of paper is very corrosive. The most common material used for the bleaching paper now is chlorine dioxide. Brominated novolac epoxy vinyl ester resins have been found to provide optimum resistance to chlorine dioxide based on testing at paper mills. The types of equipment in a paper mill that can be made out of properly designed and fabricated FRP are up flow tubes, towers, tanks, washer drums, drum covers, pipe, scrubbers, and hoods. Many case histories are also available to demonstrate the viability of FRP in these applications.

The US power industry is in the process of installing flue gas desulphurisation (FGD) units at all of its coal burning power plants to reduce the amount of acid gases that are emitted from these units. The process that is most effective in eliminating



**Fig. 4. FRP Abrasion resistant limestone slurry piping to power plant scrubber.**



Fig. 5. FRP tanks in a typical tank farm in industrial areas.

material of choice for sodium hypochlorite storage tanks is FRP constructed from brominated epoxy vinyl ester resin. When these tanks are fabricated properly, they have lasted for more than 20 years. The reasons that FRP is the material of choice are primarily its low initial cost, low maintenance costs and the long life of the tanks. Other materials of construction will either not last as long or are more that twice the cost of an FRP tank. The odour abatement systems at waste water treatment plants are also made from epoxy vinyl ester-based FRP. Scrubbers, absorber towers, ducting, grating and piping have all been made out of FRP.

To ensure a successful FRP application there are key several things that need to be considered. The first step is to determine if there is a resin appropriate for the service. Proper resin selection is very important to long service life. Information



Fig. 6. Composite cooling towers at 750MW Midwest Power Plant designed for 50-plus years service life.

required to make resin selection includes the chemicals in service, minimum and maximum concentrations, maximum temperatures, any upset conditions, abrasion requirements and any fire retardant requirements. With this information, the proper resin can be selected for the application. Most of the major resin suppliers can give assistance on resin selection through consultation with their technical personnel or by using their published resin selection guides. The next step is proper equipment design. This will include the proper corrosion liner

and structural wall construction. The third step is to write detailed specifications for the fabricator to follow. The fourth step is having the equipment fabricated. The quality of the fabricated equipment is important. An equipment fabricator should be evaluated and approved on their ability to meet the desired quality requirements in the specification. The next step is inspection of the fabricated equipment. Inspecting the equipment should be done while it is being made, when it is shipped, after it is received at the site and before it is put into service. These inspections will help insure that the equipment was made with the proper materials and that it meets the desired quality. An experienced FRP inspector is essential. An experienced inspector knows what to look for during the fabrication of FRP equipment. It is also advised to have the equipment inspected on a regular basis once it is in service to verify that it is performing they way it was intended.

## Conclusion

FRP equipment has been used successfully to mitigate corrosion in difficult environments since the early 1950s. When the proper resin is chosen, and the equipment is designed and fabricated properly, a long, maintenance-free service life can be expected. Numerous case histories are available demonstrating that FRP equipment can give very long service life. There are many applications where carbon steel and stainless steel simply cannot handle corrosive chemical environments. Currently, many corrosion engineers only consider FRP if they cannot find appropriate metals for a given application. In many of these applications FRP equipment can be used very successfully. FRP equipment should be considered as a viable material option when looking at materials of construction for new equipment. □

Enter 35 or  at [www.engineerlive.com/ede](http://www.engineerlive.com/ede)

Michael G Stevens is Senior Staff Scientist, Ashland Inc, Covington, Kentucky, USA. [www.ashland.com](http://www.ashland.com)