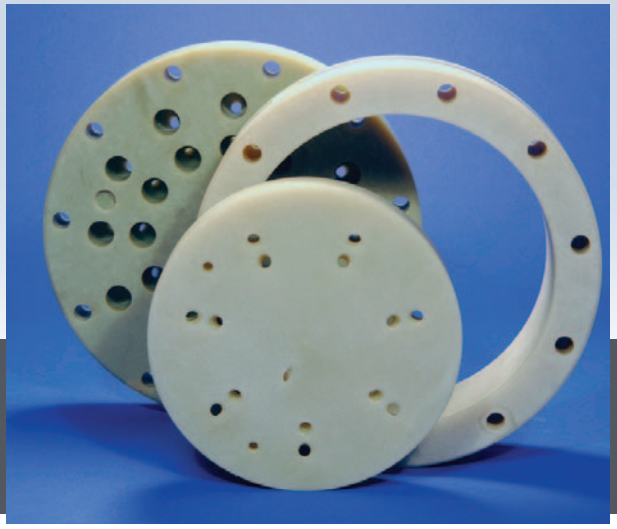
NORPLEX MICARTA

High Performance Thermoset Composites



The Norplex-Micarta thermoset composite materials machined by Amicon Plastics offer high flexural, impact, and bond strengths to withstand high pressures inside the Aqua Pump.

Thermosets Beat Pressure and Corrosion in Desalination

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A life-sustaining tool for people working at sea or in places where drinking water is not available, the patented Aqua Pump from FMC Technologies turns salt or brackish water into fresh water suitable for drinking aboard vessels and off-shore oil platforms, as well as on a battlefield in a foreign land or at natural disaster sites. But to perform this feat, the Aqua Pump produces very high pressures that put a considerable strain on the materials used to make the device. Besides handling high pressures, the materials must be able to withstand prolonged exposure to the corrosive effects of salt air, sea water, and the chemicals used to sanitize the system.

This is especially true for materials used to make a handful of pump parts that are not replaced at regular intervals. To meet the special requirements of these critical parts, the pump's designers chose thermoset composite materials. Lighter than steel and less expensive than high-end thermoplastics, thermosets provide both high strength and excellent corrosion resistance.

Reverse Osmosis Machine

To convert sea water into potable water, the Aqua Pump uses a process called reverse osmosis, in which salt water is pushed through a filtering membrane with a pressure of 1000 psi. Therefore, materials used to make the pump components must be strong enough to withstand extremely high stresses as the device operates.

To mitigate the effects of taxing operational and environmental conditions, scheduled pump maintenance calls for periodic replacement of all thermoplastic components is required. But other parts must withstand high pressures and corrosive environments for the life of the pump, which could last up to 10 years. These parts include:

- **Manifold:** Includes many ports for the passage of water. The ports are designed to direct the flow of water from suction and discharge ports to internal check valves. Creation of the ports requires complicated machining and very tight tolerances.
- **Valve body plate:** The pump's thermoplastic check valves fit into profiles machined in the valve body plate. The profiles direct the flow of water to a pumping chamber created by pistons housed in the pump body.
- **Pump body:** Houses the pistons which provide the pumping action; holds a journal bearing for rotational alignment of the cam.
- **Spacer body:** Aligns the pump body and back plate and provides a cavity for the cam rotation.
- **Back plate:** Supports the thrust generated on the cam by pistons; holds a journal bearing for rotational alignment of the cam.

Material Comparisons

Since special demands would be made of these parts, the pump's designers decided to make them out of high performance thermoset composites. Composite materials consist of fiber reinforcement in a polymer resin. The fiber provides strength and stiffness, while the resin protects the fibers and gives the material its shape.

The exceptional strength of thermoset composites allows them to withstand the high pressures inside the Aqua Pump much longer than most thermoplastics. Extremely high pressures could cause common thermoplastics to fail in a relatively short period of time. Short of outright failure, high pressures could also cause thermoplastic parts to move or "give," possibly resulting in a broken seal and a loss of pressure inside a pump.

Some high-end thermoplastics can provide the strength and corrosion resistance required by the Aqua Pump. But a thermoplastic material capable of doing the job might cost several times more than an equally capable thermoset.

As for metal alternatives, many would quickly succumb to corrosion in salt water environments. Stainless steel would fare better, but parts made of steel are three times heavier than the same parts made of thermosets. A medium-size Aqua Pump with thermoset parts that weigh 70 pounds would weigh 140 pounds more if those parts were made of steel. Weight is of particular concern because the demand to increase the fresh water output of trailer mounted reverse osmosis plants has driven designers to use lighter and smaller pumps that provide the same pressure and flow rates. On seagoing vessels, a passageway is burned through the decks to remove heavier conventional pumps for repair, a costly and time consuming process. The Aqua Pump can be carried off of a ship by one man.

The specific thermosets chosen for the Aqua Pump are NEMA Grade G10/FR4 materials consisting of a continuous woven glass fabric base impregnated with an epoxy resin binder. The materials offer high flexural, impact, and bond strength. Bond strength is particularly important for the thermoset parts in the pump. If the thermoset's inter-laminar bonds aren't strong enough, the high pressures required for reverse osmosis will separate the material layers, resulting in leakage through the openings.

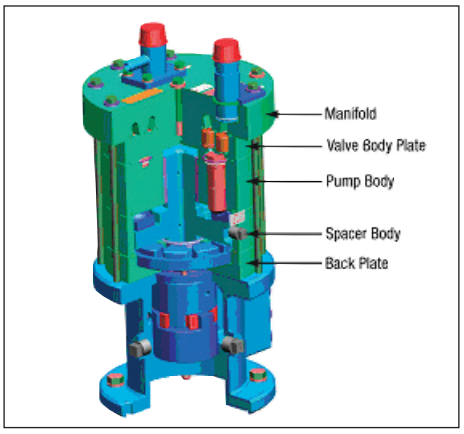
B-Stage Problems

Early in the Aqua Pump's history, the thermoset materials selected by the designers were not providing consistent bond strength. As a result, there were occasional pump failures. The problems were traced to the composite's B-stage, an intermediate stage in the reaction of a number of thermosetting resins. Composite manufacturers that take B-stage materials from dissimilar batches supplied by others cannot have precise control of critical production variables such as resin percentage and flow rate, which have a direct impact on the bond strength of the finished material.

Once the cause of the problems was discovered, FMC got some important help from a division of Plastomer Technologies, Amicon Plastics, the fabricator that machines the thermoset pump parts. Amicon turned to a new supplier, Norplex-Micarta, a leading manufacturer of high-performance thermoset composites. Norplex-Micarta manufactures and treats its own B-stage materials, which gives the company more control over the makeup and properties of its composites so it can ensure high product integrity.

Norplex-Micarta provides Amicon with two composite materials. One is RT500, a new tubing material consisting of epoxy resin and texturized woven fiberglass, which provides excellent wall bond strength and high resistance to delamination. For the thermoset parts other than tubing, the supplier provides NP510A, a sheet material that combines a woven glass fabric and an epoxy resin laminate that contains bromine. This product offers consistent quality and high flexural, impact, and bond strength.

These two materials have been excellent and consistent performers in the field. Since the switch to NP510A and RT500, FMC has reported no product failures related to the bond strength of the Aqua Pump's composites.



The following parts must withstand high pressures and corrosive environments for the life of the Aqua Pump, which could last up to 10 years.

Conclusion

For desalination pumps and other critical devices, thermoset composite materials can provide both high strength and excellent corrosion resistance. But the quality of these materials depends to some extent on the company that manufactures them. A composite supplier that keeps important production variables under tight control is the best bet to provide materials that can be counted on consistently over long periods of time in the most demanding environments.

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