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Tackling Cavitation Erosion With Polyamide-11 Powder Coatings

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For some end users, products that help extend equipment life and allow the use of lower-cost materials can be a dream-come-true.

Polyamide-11 powder coatings have been offering excellent resistance to corrosion, abrasion/impact, treatment chemicals and cleaning solutions (acidic/basic) and UV degradation for some time. In a recent discovery, however, they also have been shown to offer excellent resistance to cavitation erosion to a degree exceeding that of other coatings and stainless steel. These are important findings, especially for the water industry, where cavitation erosion is a major problem.

For example, the Water Supply Department of Hong Kong has identified cavitation erosion as the main cause of premature failure of pumps in its municipal water system. Recent work compared the cavitation erosion of metals employed in Hong Kong (cast iron, bronze, brass, copper, and stainless steel) and found stainless steel to be the best choice, by far, to address these premature failures.(1) Yet, while stainless steel often can be a good technical solution, its high cost can make it a rather impractical choice.

Hong Kong's dilemma is not unique. Cavitation erosion poses problems for pumping systems the world over. Cavitation occurs when low-pressure regions form in water moving at high velocity. In these regions, water vaporizes to form bubbles. When the bubbles move to high-pressure regions, they collapse, generating shock waves that erode nearby surfaces. This process is known as cavitation erosion, and it commonly causes premature failure of hydraulic equipment, e.g., pumps, valves, pipes, turbines, and propellers. (2, 3)

A protective coating that resists cavitation erosion can offer significant benefits to end users. Besides helping to extend equipment service life, it can allow the use of lower-cost metals as materials of construction. Polyamide-11 powder coatings are such a coating.

Water Industry History

Polyamide-11 powder coatings have a long history of use in the water industry (see Figure 1). Consider some examples:

- ***Water treatment station***

  The carbon steel pipes of the water treatment station of the city of Halle (Germany) have a Polyamide-11 powder coating both on the inside and the outside. For 13 years, this station has processed 1.5 million gallons/hour. In addition to resistance to corrosion and abrasion/impact, the specific benefit of Polyamide-11 powder coating in this operation is its resistance to treatment chemicals (oxygen, ozone, chlorine, flocculants).

- ***Portable water purification equipment***

  Infilco-Degremont, of Richmond, VA, manufactures portable water purification equipment. Factory-assembled equipment is installed where needed (the number of units commensurate with volume). Carbon steel pipes are protected inside and outside with a Polyamide-11 powder coating. These coated pipes give better overall performance than stainless steel or fiber-reinforced plastics. Currently, such equipment is serving the cities of Moscow (Russia) and Rouen (France).

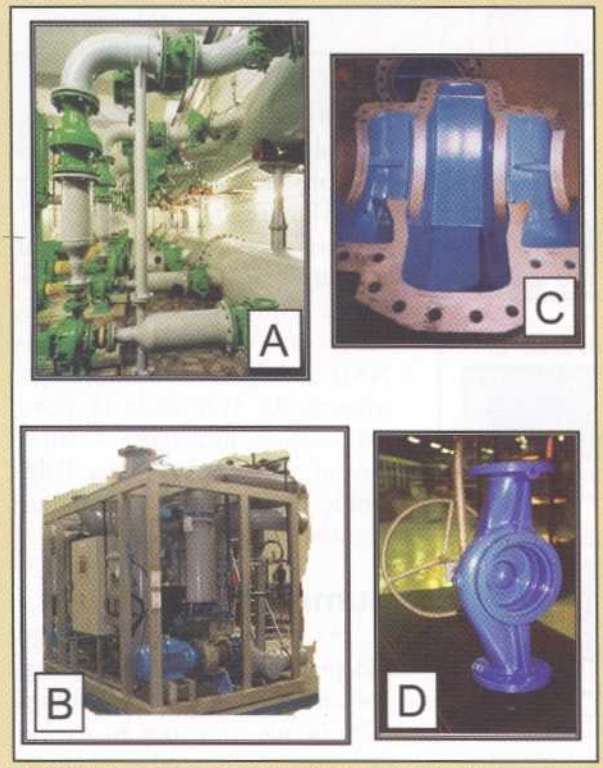

Figure 1. Typical uses of Polyamide-11 powder coatings: A. water treatment station. B. portable water purification equipment. C. split axle pump. D. pump housing.

Application

Polyamide-11 powder coatings are applied by ordinary methods—electrostatic spray, fluidized bed and thermal spray. As thermoplastics, they can be melted and cooled successively, which makes for easy application and repair. This contrasts with thermosets, like fusion-bonded epoxies, that can be melted/cooled only once.

Polyamide polymers often are called nylon polymers. Among the myriad of them developed since the 1930s, Polyamide-11 is unique. Its set of properties is ideal for coating applications. Consider Figure 2, which compares the properties of Polyamide-11 to Polyamide-6 and Polyamide-6/6, among the best known and commercially available of the polyamides. For Polyamide-11:

- the melting point (185° C) is low, enabling more convenient powder coating processing; and
- the equilibrium level of water absorption is low (~2% by weight), enabling good corrosion protection.

Further enhancing the utility of Polyamide-11 is an impact resistance of ~50 kJ/m², and resistance to a wide variety of chemicals. It is unique in another regard, too—it's not petroleum-based. The fact that Polyamide-11 is derived from castor oil, a renewable resource, makes it a truly *green product.*

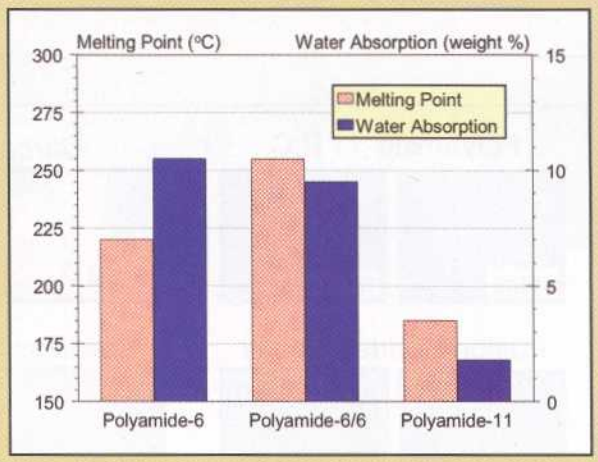

Figure 2. Comparison of polyamides

Resistance to Cavitation Erosion

Through experimental work according to ASTM G-32: *Standard Test Method for Cavitation Erosion Using Vibratory Apparatus,* an independent laboratory, KTA Tator, Inc., of Pittsburgh, PA, compared the cavitation erosion resistance of Polyamide-11 to that of powder coatings and metals commonly used in the water industry. Comparison of the tested coatings can be seen in Figure 3. Details are given elsewhere. (4)

As shown, Polyamide-11 powder coatings, compared with two commercial epoxy powder coatings, performed exceptionally. Optical data show the same (see Figure 4). For the Polyamide-11 powder coating, there is a small loss of gloss only, whereas for the epoxy powder coatings, there is erosion to the metal surface. On consideration, these results are not surprising. Crosslinked coatings, like epoxies, would not be expected to withstand the impact of cavitation-generated shock waves.

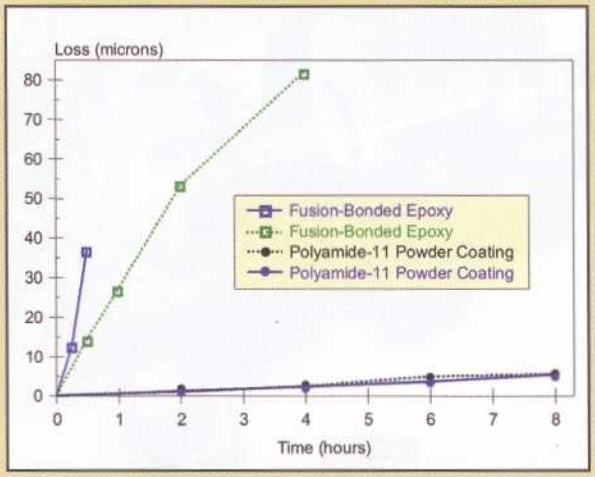

Figure 3. Comparison of coating performance showing loss of material as a function of cavitation exposure time. Greater material loss means greater cavitation erosion.

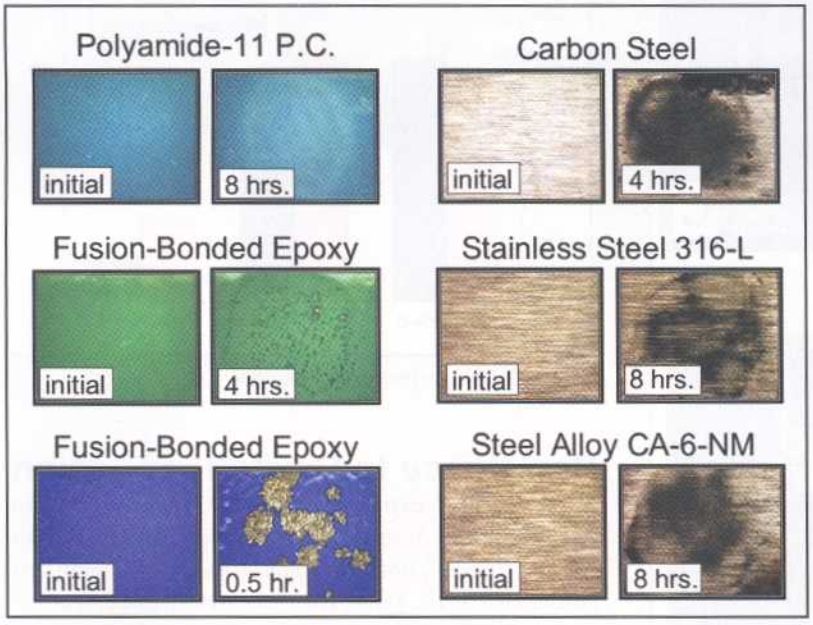

Figure 4. Optical data before and after testing

Comparison of coatings and metals is shown in Figure 5. Here, Polyamide-11 powder coatings also performed better than brass, bronze, ductile cast iron, carbon steel and stainless steel 316-L. As seen in Figure 4, optical data show the same (only steel products shown). Regarding loss (Figure 5), Polyamide-11 powder coatings perform about the same as Steel Alloy (CA-6-NM). Optical data, however, show that Steel Alloy (CA-6-NM) undergoes a visual change, whereas the Polyamide-11 powder coating undergoes a small loss of gloss only. Thus, Polyamide-11 powder coatings are regarded as better.

Summary

As demonstrated through independent laboratory testing, Polyamide-11 powder coatings offer better resistance to cavitation erosion than other coatings and metals used in the water industry—most notably stainless steels. Where cavitation erosion

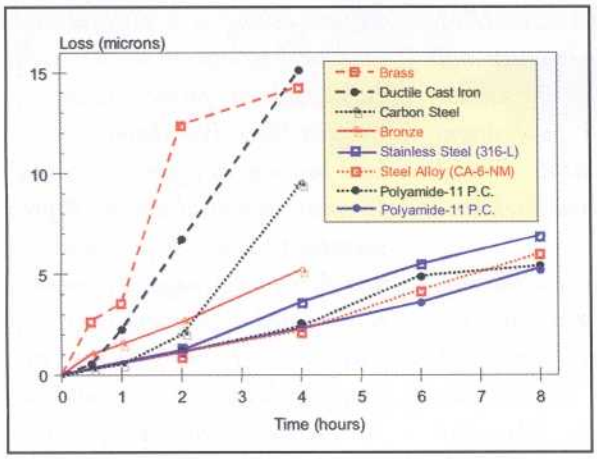

Figure 5. Comparison of coating and metal performance showing loss of material as a function of cavitation exposure time. Greater material loss means greater cavitation erosion.

is a concern, Polyamide-11 powder coatings offer a great advantage, including outstanding performance with low-cost metals. Combined with their marked resistance to corrosion, abrasion/impact and chemicals, this enhances the already strong position of Polyamide-11 powder coatings in the water and fluid flow industries. **P&S**

Acknowledgements

Philip L. Drooks of the Metropolitan Water District of Southern California (La Verne, CA) is acknowledged for highlighting the importance of the cavitation erosion phenomenon and advice on materials selection.

References

1. Chan, W.M., Cheng, F.T., and Chow, W.K. "Susceptibility of Materials to Cavitation Erosion in Hong Kong," *Journal AWWA* 94 (8), 76-84 (August 2002)
2. Lecoffre, Y. Cavitation. A.A. Balkema Publishers, Brookfield (VT) (1999)
3. Rahmeyer, W.J. "Cavitation Damage to Hydraulic Structures," *Journal AWWA,* 270-274 (May 1981)

4. McAndrew, T.P., Audenaert, M., Petersheim, J., Garcia, D., and Richards, T. "Cavitation Resistance of Polyamide-11 Powder Coatings," *Polymer Preprints,* 45 (2), 155-156 (2004)

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New Beginnings Built on Years of Success

Effective October 1, 2004, the former ATOFINA organization changed its structure and set up two new companies: Arkema and Total Petrochemicals.

Arkema Inc. offers a line of Polyamide-11 powder coating products, Rilsan®, Fine Powders, with properties/colors tailored to specific applications. They are approved world-wide for use in the water industry (in U.S. – ANSI/AWWA C-224-01, NSF-61, UL-1091), where they already enjoy a 35-year record of success. The Polyamide-11 products examined in this article were Black 7450 AC FB and Blue 7174 MAC FB.

Arkema Inc. maintains a worldwide network of approved coaters to serve clients with coatings services. For more information on the company and the products and services referenced in this article, contact Jerry Petersheim at (215) 419-7633.