Paal Skybak and **Stein Dietrichson**, Advanced Marine Coatings discuss the development of a coating, which has superior smoothness and abrasion resistance

Greener, smoother coating for ships

Paal Skybak, managing director, AMC, leads a small but formidable research team for the development of Green Ocean Coatings

Norwegian company, Advanced Marine Coatings (AMC AS), which specialises in futuristic coating systems, has harnessed a breakthrough nano-science and a patented dispersion technology to make a type of paint with exceptional abrasion resistance and smoothness.

These products, trade-named Green Ocean Coatings, could make a significant difference to a ship's speed and fuel consumption. This innovation will bring cost savings for ship owners and positive effects for the environment.

In mid-2009, AMC subjected Green Ocean Coatings to the ultimate rigorous trial – applying it to large areas of the subsea and topside of an LNG (liquefied natural gas) tanker. The ship, *Berge Arzew*, operated by leading gas marine transportation provider BW Gas, is the first vessel to test the anti-fouling version of Green Ocean Coatings. Initial monitoring has been positive and helpful in further development of this new technology.

HOW THE COATING CAME ABOUT

In 2006, the company experimented with a nano-modified epoxy coating formulation applied on a speedboat. Preliminary tests showed that the coating made a difference of several knots in terms of the speed, compared to traditional anti-fouling paints. Over the next three years, AMC continued to improve the formula. Subsequent tests on different types of boats with depths of up to 40m demonstrated an increase in speed of 6 to 10%, or a corresponding reduction in fuel consumption.

The small but formidable development team of five, who together have chalked up 120 years' experience in polymers, were determined to refine the entire coating process.

After trying several application methods such as brush, roller and component spray, the team concluded that the traditional 1-component spray method works very well and the modern 2-component spray method gives even better results.

Paal Skybak, managing director, AMC, says: "We want to deliver the greatest value to users, not only by developing an economical and ecologically friendly coating but also by advising on the best way to apply it."

HOW IT WORKS

The secret to the coating lies in the carbon nano tubes (CNT), which are evenly distributed in a liquid resin. The tubes reduce viscosity and work as a tough reinforcement to the coating. German company Bayer MaterialScience, one of the world's largest polymer companies, supplied Baytubes.

"This is the first application of Baytubes in marine coatings to our knowledge", says Dr Raul Pires, head of Global Activities for Nanotubes and Nanotechnology Products at Bayer MaterialScience. The coatings are suitable for new vessels and for subsequent repair and maintenance coatings.

Bayer's CNT are delivered in the form of lumps or agglomerates, which are normally difficult to disperse in liquids. With a patented Finnish technology, these lumps can be dissolved into separate tubes spread evenly throughout the epoxy system.

AMC went on to partner the Finnish firm Amroy Oy and has obtained worldwide exclusivity to use this technology in marine coating systems.

Skybak adds: "This is an ideal partnership. It has formed the foundation for developing several subsea and topside marine protective coatings with properties superior to those of traditionally reinforced epoxy coating systems."

Green Ocean Coatings have been applied to Norwegian catamaran ferry MS Steigtind with promising results

WHY IT IS BETTER

The nano-tubes are approximately 20 nanometres in diameter and several hundred nanometres long. Spreading out 20g of CNT will yield an area as large as the surface of a soccer stadium. Therefore, a small addition of these strong, tiny carbon tubes will improve the abrasion resistance by at least 100% compared to traditional, solvent-borne epoxy systems.

Carbon tube reinforcement is also beneficial for fatigue and dynamic mechanical properties. Most surfaces on a ship are exposed to vibration and continuous movement. In bal-

Authors:
Mr Paal Skybak, Managing Director, Advanced Marine Coatings AS, Titangaten 1, 1630 Fredrikstad, Norway. Tel: +47 4580 6288; pas@amcoat.no
Mr Stein Dietrichson, Sales & Marketing, Tel: +47 90911889; sfd@amcoat.no; www.amcoating.no

last tanks, moving steel surfaces, combined with rapid temperature changes and salt water, challenges the adhesion properties and wear resistance of the protective coating. The tubes provide a stable, flexible coating surface without having to compromise on other mechanical properties including wear resistance and adhesion to a steel surface.

The familiar UV-stabilising effect usually associated with carbon black has also been achieved by modifying epoxy with nano carbon tubes. AMC's Green Ocean Coatings can withstand long-term exposure to the African sun with less yellowing, compared to traditional epoxy coatings. This has been confirmed in weathering tests on location and in labs.

Green Ocean Coatings do not contain any thinner. The solvent-free products result in pore-free and sleek surfaces after curing. In addition to its good adhesion properties and pore-free nature, the barrier properties of the nano-reinforced coatings are superior. Therefore both deck and hull coatings based on AMC's research have shown convincing results.

By modifying the binder systems with other polymers and nano-particles, the friction and hydrophobic properties have been optimised in applications where the coatings are exposed to extreme wear and abrasion as well as dirt and chemical attacks. Hydrophobic modified surfaces are dirt repellent and development work to obtain a so-called 'Lotus Effect' is promising. The Lotus Effect refers to the very high water repellency and self-cleaning property exhibited by the leaves of the lotus flower in nature.

High quality anti-foul coatings are in high demand. After the removal of tin-based anti-fouling biocides in international shipping in 2003, new systems have proven to be less effective in many waters. Therefore, anti-fouling coatings with superior wear resistance, which can be scrubbed, have grown in popularity during the last years. Here the AMC subsea programme shows higher properties to traditional 2-component systems. By combining new biocide technology and existing nanotechnology, AMC expects to obtain superior performance in this niche field.

Since 2006, a station to test new anti-fouling systems for the Green Ocean Coatings has been in operation in the Oslo fjord area. New test stations are being set up both in Europe and in Asia, where co-operation with the National University of Singapore will boost AMC's research efforts.

HOW IT IS EVOLVING

To accelerate this development, AMC and its partners are co-operating with Norwegian research institute, SINTEF, to participate jointly in an EU 7 research programme under the name MUST (http://sintef.org/Projectweb/MUST), where an extensive network has been established. MUST involves participation from several other large European institutes and reputable industry leaders such as Daimler, Fiat, EADS, Chemetal and Sika. MUST aims to develop new nano-container technology for inhibition of corrosion and for anti-fouling prevention.

Green Ocean Coatings is widely regarded to have great potential and AMC receives sponsorship for it through a development programme funded by Innovation Norway and the Norwegian Research Council. In co-operation with the Norwegian coastal passenger ferry company, Torghatten Nord AS, several types of Green Ocean Coatings have been applied by Norwegian shipyards on ferries and tested since 2007 with promising results.

The hard coats modified with biocides or foul release systems have resulted in superior friction properties in water with reduced drag and fuel consumption. Green Ocean Coatings also reduce the emissions of CO_2, NO_X and other gaseous pollutants. With its myriad of advantages, the development of Green Ocean Coatings has become the highest priority for AMC this year.

AMC will launch Green Ocean Coatings internationally soon and intends to explore onshore uses also.