CUTTING the COST of CAVITATION

CAVITATION DAMAGE CAN RENDER EQUIPMENT USELESS IF LEFT UNTREATED, SO HERE WE LOOK AT NEW METHODS TO COMBAT THE PROBLEM

Cavitation damage on ships costs the marine industry millions every year. Shipping is a vital part of the world's economy, and so their contribution to this is dependent on keeping ships at sea. Cavitation damage is proportional to the rate of flow across the substrate. Therefore, with increasing speeds of vessels, solutions are needed to combat this phenomenon.

Cavitation is caused where rapid changes of pressure occur. This is seen in fluid flow situations and usually occurs on foils. Foils are used in many different areas in industry and are best exemplified by an aeroplane wing. In the marine industry foils are seen on the rudder, the vanes in pumps, and also the propulsion systems

Foils are used to create pressure differences for varied reasons. For an aeroplane wing, the foil is used to create lift. The flow of the fluid is caused by the foil moving through the fluid whether it is water or air. As an aeroplane is driven along the runway the wings are in a position where lift would not be present. When the aeroplane reaches a certain speed the wings are adjusted to create the lift required for take-off. The lift gained is through a pressure difference where high pressure moves towards low pressure Low pressure is caused by fluid particles moving fast around the longer edge of a foil. This means that the other side of the foil experiences comparatively high pressure.

Cavitation is apparent on the low pressure side of a foil. The formation of the vapour bubbles is where the boiling point of the fluid is reached at the lower pressure. These microscopic vapour bubbles sit close to the surface of the foil. As the flow moves towards the end of the foil, pressure rises and the vapour bubbles implode with immense force. Cavitation damage will be easily identifiable on any blade or vane as it will occur in intensive patches.

Cavitation damage can render equipment useless if left untreated. Pumps tend to show accelerated rates of cavitation due to the high rate of fluid flow across the blades. The damage resembles a substrate that has been shot blasted in one place until holes appear. There will always be varying amounts of damage depending on fluid velocity and substrate material.

Damage from cavitation can be limited in the design phase of producing the foil shape. During design, simulations can be carried out to find out the forces that the foil will be under and therefore work out the amount of cavitation and where it will occur. Slight changes to the camber and the chord length can change the forces acting upon the foil. This is the main area where the effects of cavitation can be reduced. However, cavitation may still occur and so the questions are; how is the cavitation damage repaired? And, what else can be done to prevent cavitation damage?

Millions is spent on replacing equipment damaged by cavitation. This is not only expensive and time consuming, but like for like replacement will not solve the problem. There are many alternatives m the market with varying rates of success.

Many repair methods involve welding. This is a common option and replaces metal with more metal. By overlay welding the damage, the pitted area becomes filled and then machining and polishing can bring the substrate back to looking almost like new. However, this method is just papering over the cracks. As previously mentioned, the same problem will arise. Welding is also encouraging other problems to occur.

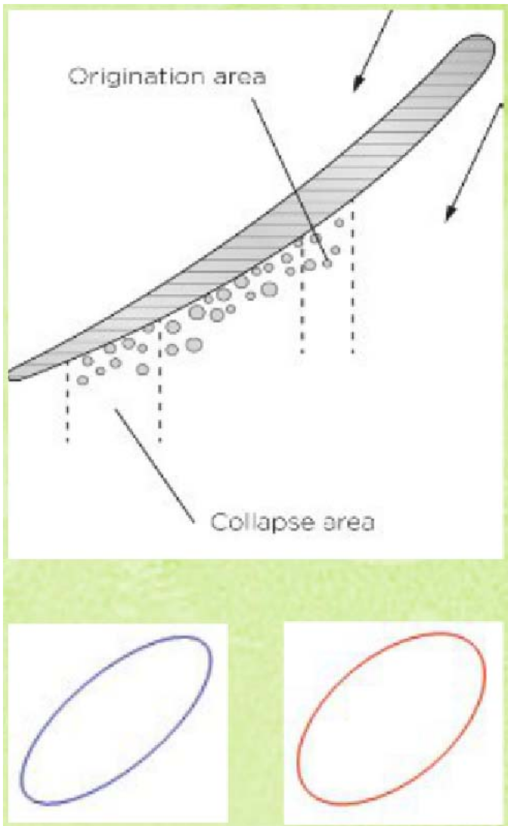


Figure I - Formation and Collapse Areas for Vapour Bubbles

Corrosion can still attack any uncoated or untreated metallic surfaces. Erosion from impingement and entrainment will still damage the substrate. Introducing heat into the substrate can cause HAZ (Heat Affected Zones) and stress corrosion cracking. Unless carefully selected, the weld alloy can introduce bi-metallic corrosion. Also, the required permits, along with needing a skilled worker, count towards the growing drawbacks when working with welding. This means thermal spraying is ruled out as well.

Figure 2 - Cavitation Damage in Identical Areas

WHAT ARE THE ALTERNATIVES?

Coatings have been on the market for decades and offer solutions to corrosion and erosion problems. Some coatings offer general corrosion resistance and shouldn't be involved in situations where there may be elevated temperatures, strong chemicals, and high erosion rates. Where cavitation occurs, low value paint systems tend to break down very quickly. Coating brand new equipment may seem like an additional expense to start with, however, a suitable long term solution can dramatically cut costs.

Therefore, it is very important to select the right solution. Epoxy coatings have advanced in recent years to be able to cope with the demands of higher temperatures and stronger chemicals to halt corrosion. Erosion and abrasion are an increasing problem in industry however, and reducing the effects and preserving the substrate will help equipment, especially when the coating will completely stop corrosion. Some epoxy coatings in the market have fillers made from alumina oxide, silicon carbide and ceramics, which actively resist the effects of erosion. The epoxy coating will still see signs of erosion (depending on the wear rates) but it is faster, easier and cheaper to repair the epoxy coating during maintenance periods compared with replacing metal by welding.

Through stringent laboratory testing and sea trials, elastomeric polymer coatings have now been developed to resist the effects of cavitation and save costly downtime. Whereas epoxy coatings are made very hard to resist general erosion, they suffer from impacts and cavitation due to brittleness. The best way of protecting a surface from strong impacts is to cushion the force. A corrosion resistant coating that will compress with impact, and then return to its original state, is the future in combatting erosion by cavitation.

INDEPENDENT TEST

Independent tests were carried out on a Belzona epoxy coating and polyurethane coating. Belzona 1341 is an efficiency enhancing, ceramic filled, epoxy product. It has a proven track record of increasing the efficiency in pumps and in fluid flow situations, as well as stopping corrosion and resisting the effects of erosion. Belzona 2141 is a relatively new polyurethane coating. It has been designed to resist the effects of cavitation and impacts, as well as stopping corrosion.

The independent testing comprised of a 500 hour erosion simulation where the products were subjected to cavitation effects. As can be seen in figures 3 and 4, the Belzona 1341 had slight damage showing in one particular area. In the same area on the Belzona 2141 there is a very slight shadow but no damage. This damage is from the effects of cavitation and proves the capabilities of a polyurethane coating.

Cavitation usually occurs in specific areas. Knowing where the cavitation areas are helps to identify the repair areas. Combining a polyurethane coating with an epoxy coating is a good way to get the benefits from both products.

Figure 3 - Belzona 1341 after erosion testing

Figure 4 - Belzona 2747 after erosion testin

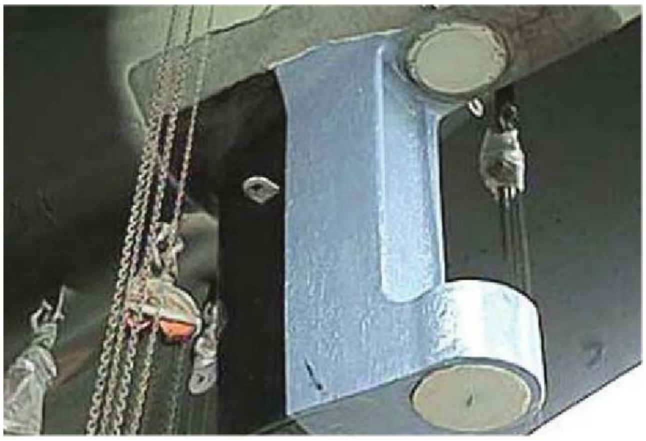


Figure 5 - Rudder horn protected with Belzona 2141 and 1341

The combination of Belzona 1341 and 2141 has given impact and cavitation resistance in the areas that were previously damaged. It also gives complete corrosion resistance and improved efficiency. Both products are hand or spray applied and will cure in a matter of hours helping to reduce downtime. When spray applied the products tend to give a smoother finish and offer a faster application on large areas.

If any piece of equipment is suffering from erosion, corrosion and specifically cavitation, efficiency of how that equipment works will be declining. Avoid costly replacement or hot work and look into polymer coatings. Coupling protective coatings with a well-scheduled maintenance programme can save your company time and money.

METALINE CONTAINERSHIP SOLUTION

Deep localised corrosion was found around the stainless steel wear ring of the bow thrusters on a 2500 TEU container vessel during its 10-year drydocking.

The stainless steel insert in the tunnel wall is made to ensure that the thruster blades are not damaging the tunnel walls through cavitation. However once the protective coating is damaged it can lead to severe galvanic corrosion between hull and ring, as well as the thruster body and ring. This is greatly enhanced through cavitation while the thruster is in operation.

The typical damage pattern includes localised but very deep crevices close to the stainless steel ring, with a depth of material loss of up to 95% of the wall thickness being common. The welded seams connecting the stainless steel ring to the hull are particularly affected.

Until now, the solution for this problem employed by the owner was the introduction of high abrasion resistant epoxy paint or ceramic filler and/or the introduction of additional zinc or aluminium sacrificial anodes. While the hard coating was eroded quite quickly, the anodes created an additional problem. The induced electric current produced by the anodes was actually rupturing the paint locally, thus creating additional hot spots for galvanic erosion.

CET-Hamburg was invited to analyse the problem, and after thorough investigation it was agreed that the stainless steel ring, plus areas where visible erosion and paint loss occurred, were to be covered by Metaline 785. The actual ring surface was covered to ensure that no galvanic corrosion occurs between wear ring and thruster body.

The steel structure was reinstated by welding and grinding to classification society standards.

The thruster in its drydocking condition

Due to the crevice layout, deep local welding was necessary with multiple bead welding. The welding was followed by dry blasting the surface to SA2 standard to create a good surface profile After the blasting inspection, the surface was cleaned and coated with Metaline 924. Due to the very uneven welding bead surface, a stripe coating was applied initially in the welding area. Roughly six hours after primer application, the base coat Metaline 900 was applied, preparing for the final elastomer application.

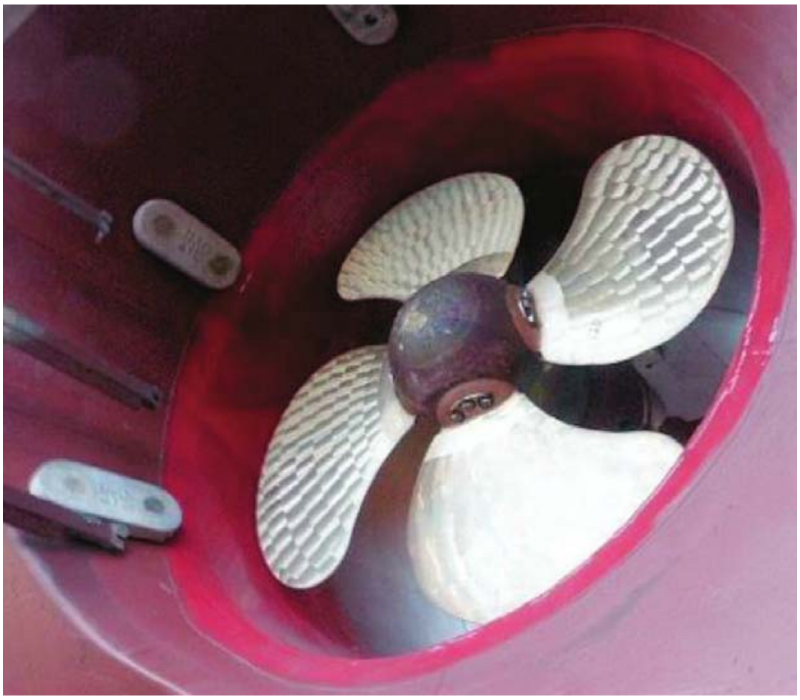
CONSTANT APPLICATION PROCESS

Following a 1hr curing time of the base coat, the application of Metaline 785 was started using a simple, yet effective, air driven application gun, as it is delivered ready for use in oneway 1kg cartridges. Due to the over coating time of one to two minutes, a constant application process can be maintained, resulting in a technically sound and very eye-pleasing elastomer coating.

The application was done using two different colours. The final coat was applied in red at the request of the owner, while the main thickness was generated in a green colour. In case of extensive wear at any given location, the red top layer may be worn away exposing the green underlying material. This will give a clear and easy indication of wear hot spots which can be immediately identified by divers, even in very poor visibility.

The remaining blasted area was coated with the owner's normal underwater paint scheme, employing epoxy coatings as well as an antifouling paint 36 hours after the application of Metaline 785, the bow thruster unit was installed. The whole Metaline application, including blasting was done in 24hrs, plus curing time. The docking time was not affected in any way, and the application could be easily integrated into the docking window.

Deep localised corrosion was found around the stainless steel wearing requiring that it be re-welded



The thuster after welding, (top) the covered welding area, (center) the coating cross section; the final result

ECOSHIELD RUDDER APPLICATION

In August, several rudders were coated with Hydrex's Ecoshield in China and the US. In China, the rudders of a 261 and a 209m container ship were coated in Guangzhou and Changxing Island, while a 228m vehicle carrier had its rudder coated in Zhoushan. Around the same time Ecoshield was applied on both the rudders of a 46m tug in Mobile, Alabama.

Cavitation erosion damage had appeared on the rudders of these vessels, so the owners had decided to use Ecoshield in order to prevent similar damage from occurring again.

The coating provides the rudder with an impenetrable protective layer. At the same time its toughness and flexibility enables absorption of the forces that are produced by cavitation. This prevents the damage normally caused by this phenomenon. Without proper protection against cavitation and the resulting erosion and corrosion damage, the financial consequences can be severe.

Ecoshield is guaranteed for ten years, so with an Ecoshield application no repaint will be needed during drydocking periods, with at most, minor touch-ups being required Planning the maintenance of the vessel's stern area therefore becomes much easier. The smoothness attained by the coating also provides optimum hydrodynamic conditions.

This allows rudders to operate at maximum efficiency. The ship's
performance therefore remains stable and the owner's investment rs secured. Ecoshield is also ideally suited for other areas prone to cavitation erosion or other damage, such as propeller nozzles, thruster tunnels, the bulbous bow or stabilizer fins. For this reason the tugboat also had both its nozzles coated and both container vessels had Ecoshield applied to their thruster tunnels.

Source: Drydock-Magazine December 2013
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