CASE STUDY

REDUCTION WEAR ON ROLLS ROYCE AQUAMASTER US 17-01 VESSEL SD JACOBA, KOTUG INTERNATIONAL BV, ROTTERDAM

PRODUCTS TESTED

Archoil AR9100 Nanoborate Oil Treatment (Friction Modifier)

PARTIES & INDIVIDUALS:

Kotug Internationall on SD Jacoba is supervised by Jan Groeneweg, Technical Superintendent and Koos Smoor, Group Technical Manager. BLP International Hillegom, Project Manager - Rob van Hoorn.

PERIOD:

December 2011 - July 16th 2012.

BACKGROUND:

With a century of experience combined with a modern fleet, KOTUG has built its reputation as a competitive and innovative player in the maritime industry for harbour towage, coastal & deep sea towage, salvage and emergency response, tug management, chartering, brokerage, offshore services and assistance to the dredging industry.

As of December 2011 Kotug International started to deploy Archoil AR9100 Nano-Borate formulated friction modifier in 2 of their Rolls-Royce US 17-01 Azimuth thrusters on its tug SD Jacoba.

THERE ARE THREE OBJECTIVES:

- The operating temperatures of the RR thrusters cause the Shell Omala gear-oil to degrade fast. Up until December 2011 the thrusters reached base-line oil temperatures of around 94° C in tropical waters and 84°C in nordic waters.
- The wear and tear of the RR thrusters create a lot of soot, high PPM values of different elements like Fe, Cu and Sn and high TAN values in the thrusters' oil system. The higher TAN causes a drop in the oils' flashpoint by 30°C. Both the temperature and the contamination make a complete oil-drain of 1,300 litres per thruster necessary every year (appr. 2,200 operating hours). Filters have to be changed much more often than expected.
- The RR Aquamaster thrusters themselves wear out within four to five years, demonstrating extensive damage to bearings, sliding parts, oil channels and bolts. This makes it necessary to completely overhaul the thrusters every 4 to 5 years. This, along with the downtime and docking-time increases running costs significantly.

It is expected that Archoil's AR9100 Nano-Borate friction modifier will resolve these problems.

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A BRIEF EXPLANATION OF THE NANOTECHNIQUE USED IN AR9100:

At the beginning of the 90's it was discovered that boric lubricants are one of the most slippery in existence. Earlier tests showed that thin films or bulk powders of boric acid could provide friction coefficients as low as 0.02 to 0.05 — one-fourth to one-sixth the value of other, more expensive solid and liquid lubricants. Other treated powders, like ceramics and tungsten, can share similar properties and or even outperform boric acid. Mid 00's, Archoil's patented nano-boric liquid media additives containing proprietary (boron or other elements) compounds proved to work even better. Specifically, when used as solid dispersion or liquid media additives in lubricating mineral and synthetic base oils, they were able to reduce friction by 50% to 90% (depending on the concentration) and under a wide range of boundary-lubricated sliding conditions. These novel additives were also able to enhance, for instance the lubricity of sulphur-free and ultra-low sulphur diesel fuels. They reduced wear-scar diameters by as much as 50% in high-frequency reciprocating and ball-on-three disk fuel lubricity tests.

Archoil's nanotechniques represent a 2nd generation in this particular field. As part of these 2.0 nanotechniques, Archoil's nanoborate has unique ability to reduce boron size down to the more efficient 'nano' level and deliver it in a naturally occurring fatty acid ester matrix carrier. This proprietary ester carrier is specially formulated to facilitate the migration of the protective boron nanoparticles to the metal surface. The unusual mechanism of nanoboric lubrication in these fluids, oils and fuels is controlled by its chemical structure and its ability to form a strongly bonded protective boundary film on rubbing surfaces. The compound is crystallized in layers in which the atoms are tightly bonded to each other. The layers themselves are weakly bonded; when stressed, they shear and slide over one another easily, so friction is low. The strong bonding between the layers prevents direct contact between metal sliding parts, minimizing wear. Nanoborate does not separate, nor need longer bonding times to the metal as previous boric acid did.

The surface created also prevents oxidation. These bonds are so strong that pre-existing dirt, rust and carbon varnishes are displaced. These virtually indestructible bonds literally change the metal surface's characteristics and create a self healing friction barrier. This translates to extremely low-friction coefficient (under 0.038 percent) between the platelets and the metal surfaces they separate. This friction barrier is nearly permanent for the life of the metal treated.

Assuming it is just a process of taking an oil from the shelf and blending some boron powder would be a mistake.

The key ingredient for in the specific Archoil AR9100 application is hydrated boron, a nonmetallic element also known as sassolite or borofax. Molecular hydrated boron is super slippery. Ultra fine particles are reduced to less than 1 micron (.000039 inches) by a revolutionary jet-milling process

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at sub-zero temperatures. The submicrometer hydrated boron particles can invade microscopic spaces and actually chemically BOND to metal surfaces. It therefore can withstand abrasion, washing, heat, pressure and rotation.

APPROACH:

To handle the situation on board of the SD Jacoba, BLP International has chosen to use Nano-Borate lubricants. Archoil AR9100 Nano-Borate friction modifier forms a molecular bond with the metal surface, developing a lattice structure with strong anti-corrosive properties and reducing the friction between metal surfaces significantly compared to conventional lubricants and fluids. Once in place, the lattice structure no longer depends on the carrier (fluid) and remains on the metal, despite any contamination and water that may be polluting the fluid. The metal is now protected from scuffing (welding), seizure (shearing), threadwelding (galling) or corrosion (pitting). Wear of the parts is prevented by the lattice structure that provides a coefficient of friction of <0.038 and withstands pressure of up to 4,000 kg per cm^2. It is known that the RR Aquamaster typically operates with 40 bar pressure.

The carrier of the chemical process is an Archoil patented ester. Because of its high detergency, parts cleaning can be reduced. The ester can be used in water-reducible formulations and is particularly effective in invert emulsions. AR9100 has a very good reputation when it comes to wear-protection properties and is completely stable. There is no loss of viscosity. This provides much longer lubrication intervals, especially advantageous in bearings or where no change or addition is possible. This seems to fit the situation as is the case at the SD Jacoba.

Archoil AR9100 does not hold solids and in combination with the nano-borate formulation keeps the dirt and heat away. Lastly, the AR9100 estermatrix is non toxic or acidic. This is also an advantage as today we see many EP-packages greases and oils, such as PTFE, molybdenum, sulphur, graphite, phosphorus, lead, antimony and phenols that are heavily contaminating the environment they work in. A must, as Kotug International maintains a name of being one of Europe's greenest ship owning company.

RESULTS - KOTUG INTERNATIONAL COMMENTS AFTER 7 MONTHS OF USE:

The project at Kotug Internationall on SD Jacoba is supervised by Jan Groeneweg, technical superintendent and Koos Smoor, group technical manager. The SD Jacoba is a 4000 HP twin Azimuth stern drive tugboat. The sailing area covers North Atlantic, North Sea, South Atlantic.

"After removal of previously used oil, paint and sludge on the faces of the gearteeth and housing, rails we replaced the wasted-oil with Shell Omala 68 blended 1:10 with Archoil AR9100. We have monitored the oil condition since. After 7 months we see that the Archoil AR9100 has lowered the

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base-line temperatures of the thrusters by more than 10°C. Furthermore we can clearly see that the forming of Fe PPM in the oil is minimal since AR9100 was deployed; a drop from 457 mg/kg to 111 mg/kg. The other values, like Sn and Cu remain low, TAN value do not rise." In the nearby future Rolls Royce and Kotug will open up the entire thruster to obtain an exact view of the impact of AR9100".

"For sure we are going to use AR9100 again. It saves us a lot of draining and rebuilding. Both Shell Omala and the thrusters themselves remain in very good condition. We were a little cautious as we have the clutch operating in the same oil. However, the clutch remained firm, operates very well and is actually not wearing out anymore. The drop in operating temperatures improves and raises confidence that everything is better lubricated inside the thrusters. This saves a lot of work for both sides, not to mention the financial impact of docking and down-time of the vessel".

"Overall, our findings so far have been very positive. The results relating to lubrication, corrosion and stability in all weathers, climates and situations are all reasons to continue use of Archoil AR9100 nanoborate friction modifier. I guess you can say that nanoborate cannot be compared to conventional greasing".

For further information please contact BLP International, +31 252-746011 and ask for Rob van Hoorn, Project Manager. Contact Kotug International on request.

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