Water removal from thruster lubricants using new technologies

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Water in thruster lube oil is causing unscheduled docking and cost millions of dollars for vessel operator's worldwide. Unfortunately, stopping the water ingress completely is a nearly impossible task and new bio-lubes and Environmental Acceptable Lubricants (EAL) cling on to water like there is no tomorrow. The problem is that most EALs will degrade with water as catalyst and create acid, which result in severely high AN values - 19,4 mgKOH has been seen!

To avoid such issues, the Classification Society, DNV-GL, states in their e-Newsletter of June 12th, 2013: 'If bio-degradable oil is used, an arrangement shall be in place to keep the water content of the oil under control.'

This paper will focus on technologies which can keep the lubricant clean and dry, and thus ensure thruster uptime.

Water ingress in thrusters

The main cause of water ingress into the thruster lubricant is through the propeller shaft seal. This is due to:

- Fishing gear, rope or wire being caught in the propeller shaft and damaging the shaft seal
- Worn or otherwise damaged seals will allow water to ingress due to periodic heaving of the vessel in heavy seas
- When the thruster is operating, the shaft seals can perform a pumping action that will overcome the static oil pressure from the header tank
- The dynamic water pressure created by the propeller blades can exceed the static oil pressure on the shaft seal

Shaft seal wear is often caused by particle contamination in oil. Even particles less than one micron in size can have an abrasive effect on the seal, since its dynamic tolerance is less than 0.5 micron.

Picture 1, azimuth thruster, by Rolls-Royce

New thruster lubricants

Due to the revised Vessel General Permit (VGP2013) a number of bio-lubes and EAL's have been developed to meet the demands. The main reasons for choosing an EAL or any other eco-friendly fluid include the following:

- Does not produce sheen on water (emulsifies quickly with a low environmental impact);
- Readily biodegradable (60% in 28 days, ASTM D5864); and
- Required by law in some regions (vessels in US waters need EALs on marine stern tubes, thrusters etc.)

The EALs are quite different from mineral-based lubricants and each type of base stock has pros and cons (see table below).

EALs available today

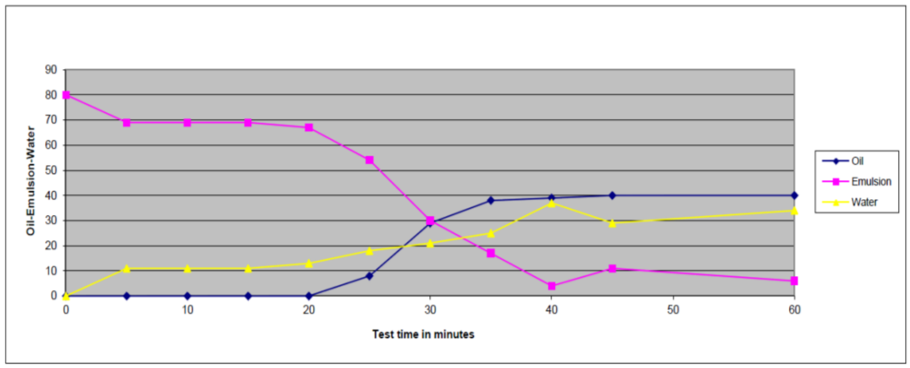
Types of EAL / eco-friendly fluids				
	Base oil	**Constituents**	**Merits**	**Drawbacks**
Triglycerides (natural esters)	Vegetable oil based on: rapeseed, sunflower, soya, mustard oil etc.	Variety of fatty acids; about 12 types plus additives	Readily biodegradable; high viscosity index (VI); good anti-wear; high flash point; compatibility with seals	Poor thermal and oxidation stability; poor cold flow behaviour; poor hydrolytic stability (‘water allergy’)
Synthetic esters	Organic acids and alcohols/phenols - chemically synthesized	Variety of fatty acids plus additives	Better properties than triglycerides; some types compatible with mineral oils; good fire resistance	More expensive than triglycerides; poor oxidation and hydrolytic stability (‘water allergy’)
Polyglycols	Many varieties; poly-alkylene (PAG) and poly-ethylene glycols (PEG) are most common	Mixture of glycols plus additives	Water soluble; good oxidation stability and doesn’t create sludge. Fire-resisting properties; high VI; good for high operating temperatures	Incompatible with many seals, paints and materials. Cannot be mixed with any other fluids; high water content can create microbes; expensive.
Poly-Alpha-Olefins	Synthetic PAO fluid, API group IV. Hydro-Carbons originating from crude oil, coal etc.	PAO fluid plus additives. May be mixed with synthetic esters	Good oxidation stability and low risk of degradation with water; good anti-wear; compatibility with seals	Not from renewable source; limited bio-degradability; risk of additive wash out; expensive. Not approved for all bio-applications.

Polyglycol-based fluids (PAG, PEG) can dissolve a lot of water and content above 5000 ppm are not uncommon. Even though the water content is high the glycol can maintain its lubricity, but since higher water levels may cause micro-pitting and hydrogen-embrittlement of machine components, the water content should be reduced. Seawater ingress also contains biologic components (e.g. microbes, algae, bacteria).

Water Separability (Demulsibility)
How well a lubricant separates water is measured using the demulsibility test (ASTM D1401).
Oil manufacturers will carry out this test at 82°C using distilled water. Some labs will however run this test at a more realistic operating temperature of 54°C. In a marine application, such as a propulsion thruster, seawater will be the main contaminant, so it is recommended to run the test with a 3.5% NaCl solution. The oil’s ability to separate water from seawater can significantly affect the results compared to using distilled water.

If water separation equipment using the coalescer principle is used, it is important to check the oil's ability to separate water. The criteria for success is to separate oil/water within 20 minutes and have a maximum of 3 ml emulsion.

Figure 2. Demulsibility test showing oil, emulsion and free-water phases. Using seawater gives a poor separation result of 29/30/21 (30 min).



Technologies for water removal

The Classification Society, DNV-GL, states in their e-Newsletter of June 12th, 2013: 'If bio-degradable oil is used, an arrangement shall be in place to keep the water content of the oil under control.'

By continuously removing sea water from the thruster lubricant the vessel can continue to operate, despite of water ingression. The need to keep thruster lubricants clean and water free is most often done utilizing one of the following equipment types installed offline:

1. Filtration using a water absorption media
2. Separation using the coalescer principle
3. Vacuum dehydration
4. Desorption (using dry air)

Method 1 is utilizing either cellulose or other super absorbent to remove water from the lubricant. These can be combined with fine filtration removing particles and normally has the lowest cost of installation.
However, in cases of severe water ingress operators will need to change out numerous water-logged filter inserts to avoid water built-up in the thruster lubricant.

RMF OLU1D filter. Source Filter Teknik/RMF

Method 2, using natural separation (coalescence) or speeding up the separation by a centrifuge is an old well known technology. This works great for oil types which readily shed water i.e. having a demulsibility test result of less than 3 ml emulsions in maximum 20 minutes. Many of the new bio lubes and EALs cannot meet this, so the efficiency of this technology is not sufficient for these types of lubricants. Getting below 2000 ppm water in oil may not be possible on EALs using a coalescer.

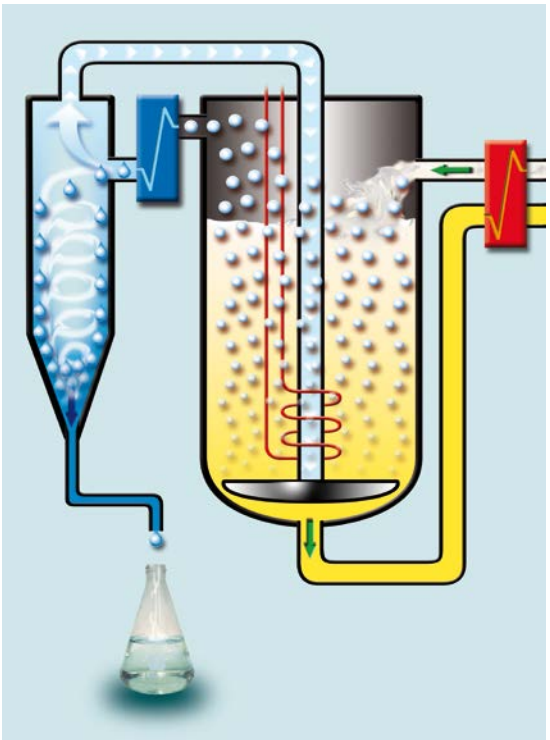
Separator using coalescence, CJC™ PTU2 Thruster Filter. Source C.C.JENSEN

Method 3, using vacuum technology to evaporate water from the lubricant at normal operating temperature is an effective way to dry out most lubricants. The technology has been used for decades on closed systems like transformers. However, the more water in the oil, the more difficult it will be to obtain vacuum in the chamber. A high amount of water will violently boil off creating foam in the vacuum chamber. The vacuum pump has to cut out momentarily to reduce the foaming and avoid oil being sucked out with the moisture.
Vacuum dehydrators have not been seen much on thruster applications, so their efficiency on EALs and bio-lubes have not yet been documented.

The technology operates as batch treatment i.e. drawing in the contaminated lubricant and processing it until the water level is low. The capacity will therefore be reduced with increasing amount of water in the lubricant.
If the water ingress is high a vacuum dehydrator cannot keep up, which will result in increasing water content in the lubricant.
Also be aware that vacuum treatment will only remove H_2O, leaving lime scale, Sodium and other salt crystals in the lubricant. A post filtration using 3-5 micron is recommended to reduce the risk of increasing concentration of salts and of course reduce particle contamination such as wear and rust.

Vacuum dehydrator, Sentinel, including post filter. Source Parker

Method 4, using dry air to remove water is also referred to as the desorption principle. Here, dry and cold air/gas is circulated though the lubricant. Cold and dry air bubbles will by nature want to pickup moisture from the surroundings and thereby reduce the water content in the lubricant. This technology is effective even for very high water contents up to 30% water in oil. Most oil types will reach 300-500 ppm water after treatment. The desorber unit is available in a “Combi” version including a post fine filter to ensure reduction of Sodium and other salt crystals in the fluid. This will also ensure low particle and varnish content.
Since the implementation of EALs and bio-lubes this technology has been thoroughly tested on all commonly used EALs. Desorbers are installed on numerous thruster applications with excellent results (see case page 7).



Desorption working principle

CJC™ Desorber D10 Combi-unit, D10/HDU

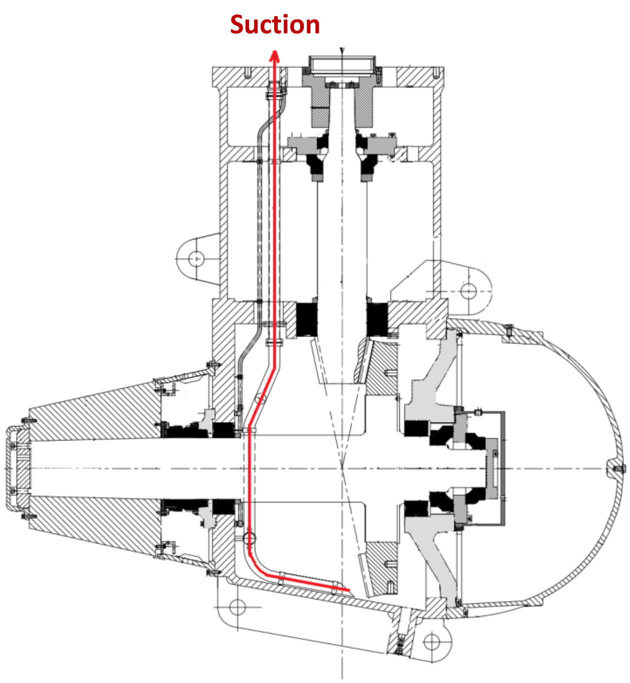
Water separation from new types of thruster lubricants will push the market towards using more advanced technologies like desorption, to ensure continued vessel operation and deferring the potential docking to a later date.
Especially for supply vessels and anchor handling tugs, this could mean the difference between being able to complete a delivery/contract or to come off-hire to fix a leak - usually involving dry-docking the vessel.

When selecting thruster oil maintenance equipment, it is important to ask for a solution which can take care of water as well as particle and varnish contamination. This will extend the life of the lubricant, plus the life of shaft seal(s), gears, bearings and all other components in the system.

Installation of water removal equipment on thrusters

The ideal solution is to take suction from the lowest part of the lower gearbox. With fixed thrusters e.g. tunnel thrusters this is possible, but with azimuth thrusters it is difficult due to the fact that they can rotate 360 degrees.
The best is to design an azimuth thruster to facilitate the connection of continuous operating oil maintenance equipment, which should take suction from the lower gear and shaft seal section. This is where particles and water will build-up when the thruster is not running.
In some cases the circulation of the lubricant in operation is enough to pick up dirt and water and remove the contaminants when connecting the maintenance equipment to the upper section of the thruster .
Please see installation drawing below.

Best practice installation of thruster oil maintenance equipment



Source Rolls-Royce

Case - oil maintenance utilizing a desorbtion and filter combination unit

The CJC™ D10 “Combi” unit was installed to purify the thruster oil Mobil Gear 600 XP 150. This lubricant typically emulsifies with water, giving a demulsibility test result of approx. 30 ml emulsion after 30 minutes.

Before installation the content of sea water in the lubricant was very high - above 17.000 ppm (1,7%). The Sodium content was too high as well (68 ppm). Oil samples were analyzed after 3,5 hours and 21 hours of operating the Desorber Filter combination.

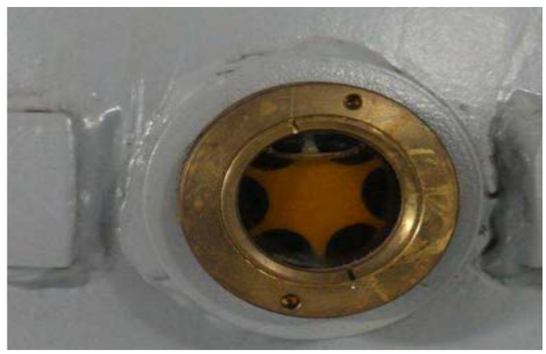
The results and photos below speak for themselves.

Oil sample at startup	**After 3,5 hours**	**After 21 hours**
Water.........**17.062 ppm**	Water.........**1.532 ppm**	Water..........**119 ppm**
Sodium...........**67,9 ppm**	Sodium...........**6,9 ppm**	Sodium.........**0,4 ppm**
ISO Code.........**16/15/10**	ISO Code.........**14/13/9**	ISO Code.......**13/12/9**

Please see other photos of installations below.

CJC™ D10 Desorber on Schottel thruster

Before installation



After treatment with desorber

Conclusion

It may be necessary to accept water in thruster lubricants, but breakdown and docking can still be avoided even when using new EALs and other bio-lubes. There are proven, efficient methods of removing water from the lubricant, making it possible to continue operating the vessel despite of water ingress in the thruster.

References

Schottel thrusters
Roll-Royce thrusters
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Brief about the author

Steffen Nyman earned his B.Sc. degree in Mechanical Engineering 1996 and was in technical sales for three and a half years. Since February 2000 he has been responsible for developing and conducting technical training and documentation for sales, service and technical staff. He has conducted hundreds of customized seminars in understanding oil maintenance including oil filtration technologies for the Marine, Mining, Power, Off-Shore and Wind industries.

He is certified Machinery Lubrication Analyst I & Technician II as well as 4-MAT trainer in adult teaching skills. Through the company CleanOilCon, Steffen has been representing Noria Corporation as License Partner in Denmark, Norway and Sweden since Dec. 2012.

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