10 Years Overhaul Interval with Gearless Azipod Thruster

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Abstract
Driven by increasing cost pressure and remote operating locations, maintenance as a major running cost element plays crucial role on way to optimized and uninterrupted operations. Essential to station keeping in dynamically positioned vessels, underwater demountable thrusters often set the pace for maintenance intervals and related downtime. Attributed by high number of potential failure modes due to numerous critical moving parts and high oil cleanliness requirement, geared power transmission is more sensitive to wear and tear and consequently premature failures. Possible failures include also ones in support systems such as oil circulation, cleaning and cooling. Higher reliability and extended maintenance intervals are enabled by eliminating most potential root causes, namely gears and unnecessary bearings and their subsystems.

Azipod gearless thrusters have been serving in two DP rigs since 2004 and 2005. In the end of 2013, last three of 2004 installed thrusters were dismantled for scheduled maintenance after about 9 years of use. As expected based on findings from earlier overhauls, all components were in extremely good condition and showed only minimal wear even after such a long use. This paper discuss these findings in detail and explains why 10 years maintenance interval is reachable with gearless Azipod C thruster.

Introduction
In 2004, sixteen electric pod thruster units (3.3 MW power each) were installed on two semisubmersible vessels under construction in Singapore. These vessels were delivered by the shipyard in spring 2005, and sailed from Singapore to the Gulf of Mexico, self-propelled by the new electric podded thrusters.

After a challenging initial service period in the Gulf (summer included two major hurricanes, Katrina and Rita), the vessels finally started operation as 2005 drew to a close.

The vessels carried one spare thruster unit on their initial journey. Thusters are designed for underwater removal and installation.

Four additional thruster units were delivered in 2008 for maintenance rotation, and thruster maintenance sequencing began in 2009. [1]

This paper describes findings from the final set of thrusters that arrived for scheduled overhaul on Nov 2013 after about nine years in operation. Focus is on the most critical components, such as bearings and seals, and photos from disassembled components are presented.

This topic was discussed first time in 2011 Dynamic Positioning Conference by Varis & Laakkonen [1], when first thrusters were overhauled after five to six years of in DP operation.
Pod thruster
In pod thrusters, the electric motor is mounted directly on the propeller shaft. This results gearless drivetrain and reduces significantly the total number of other critical components including bearings, shafts and seals compared to conventional geared thrusters. In addition, the amount of lubrication oil in gearless thruster is some 100 litres compared to normally 5000 litres and lubricant type can be selected according to bearing requirements alone.

Motor module
The motor module is a simple mechanical design—only the necessary components to provide propulsion thrust are included. The main parts are the permanent magnet motor with frame, bearings, seals and service brake; any other control or monitoring systems are installed in the thruster room inside the vessel—with the exception of monitoring sensors in both electric motor and bearings.

The motor can be driven both directions of rotation with full torque capacity, however, due to the propeller’s hydrodynamic features, negative rotation direction produces reduced thrust.

The propulsion motor, bearings and seals are directly cooled by the surrounding sea water. The motor module is pressurized with the vessel’s compressed air supply. A slight positive internal pressure is created, and small airflow pumps liquids out from the water-lubricated outer seal chamber.

Both bearings are cooled by surrounding sea water. The drive-end (DE) bearing is a grease-lubricated cylindrical rolling bearing, while the non-drive-end (NDE) bearing is an oil-sump-lubricated spherical
thrust bearing, see the image below. Oil in the thrust-bearing oil sump, less than 100 liters per unit, can be changed from inside the vessel by using the internal pressure of the motor module. The bearing is designed to withstand full-thrust force in both directions, and the housing is equipped with electric insulation to eliminate possible bearing currents.

The shaft seal system is a combination of a face-type primary seal and additional backup lip seals. The primary seal is a water-lubricated ceramic type face seal. Backup seals include two grease-lubricated lip-type seals, which provide redundancy between the primary seal and the bearing. The water leakage and therefore the condition of the primary seal can be monitored from inside the vessel using monitoring cups.

Steering module

The steering system is a fully electric steering drive. The steering module (refer to the image below) incorporates the sliprings for the main power supply and control lines; a swivel joint for grease, oil, and pressurized air supplies; a slewing bearing with seals and steering motors with planetary gears; an automatic greasing unit with piping; and, main and auxiliary terminal boxes.

Experience

Operational experience with the pod thrusters has been very good. ABB gearless thrusters have proven their performance in demanding DP application. No reduction of semisubmersible drilling rig performance has been attributed to the pod thrusters and, according to the drilling rig operator, the pod thrusters have delivered the reliability needed for drilling operations.

Wearing parts of several thrusters have been replaced with new or refurbished ones as part of maintenance operations. The thruster change-outs have been performed while the drilling rigs have been floating. Typical thruster changeover time is 12 hours for change-out and 12 hours for change-in. The thrusters have generally been in very good condition after years of operation; all the thrusters that were removed for planned maintenance were still fully capable for continuous operation with minimal signs of wear.
The changeout and overhaul schedule was based on the vessel owner’s drilling schedule; all the operations were conducted while the vessel was in transit, or out of drilling operations for some other reason.

Maintenance rotation started in June 2009 with a first set of four thrusters dismounted from Vessel 2 (refer to the photos below). These units had been in operation over 32,000 hours. The second set of five pod thruster units from Vessel 1 was changed in June 2010 after approximately 40,000 operating hours. A third overhaul set of four units from Vessel 2 was changed in February 2011 after 47,000 hours of operation. The final overhaul set of three thrusters from Vessel 1 was changed out in Nov 2013 after abt. nine years and estimated 70,000 hours of operation.

Component condition after abt. nine years of operation

The final three of the originally installed thrusters arrived for maintenance overhaul to ABB workshop facility in Houston in Nov 2013—after they served abt. nine years in operation. The thrusters were disassembled and the condition of all critical components were inspected and recorded.
Shaft seal

Even the unit had been in operation close to nine years, the shaft seal was in remarkably good condition. The primary seal of ceramic face type showed very low wear. Due to primary seal functioning well, air flow through the backup lip seals had kept them only lightly loaded as designed, ending up in a minimal wear for backup lip seals. Also the running tracks on rotating liner were remarkably shallow.

The seal housing and liner showed some corrosion, however, not in a magnitude that would have been risk for seal functioning and looked typical considering the long time in the water. Based on the findings already on the previous maintenance overhauls, the original seal design have been updated to all overhauled thrusters to extend the lifetime even further. The spring compression force has been adjusted to reduce load on the ceramic face seal, and both the counterpart of the sliding ring design and the type of sliding ring glue have been changed. Liner material and the intermediate sleeve material has been changed to avoid possible corrosion of the sleeve. On the back-up seal, a third static lip seal has been added to increase the lifespan and redundancy of the seal package, and the lip material has been changed to reduce the seal hardening during aging.
Shaftline bearings

Both propeller and thrust bearing were in excellent condition. For example, the original grinding texture was still visible in thrust bearing raceways. Normal running marks on rollers indicate that they have been working as planned. See the pictures below.

Closed oil sump with less than 100 liters of oil per thruster has clearly proven to be reliable lubrication solution for thrust bearing as well as the separate grease lubrication for propeller bearing.

Slewing seal

There was only minimal wear on three slewing seals of lip type, the lowest lip closest to water having more wear than two upper ones. Normal seal running trails were visible on liner and one spacer ring will be removed on next assembly to move seal position upwards. No indication of water leakage over slewing seal was present.
Slewing bearing and slewing gear

Slewing bearing rollers and both inner and outer raceway showed little to none visible wear. The slewing gear teeth was in very good condition as well and showed only normal marks from operation.

Motor

The propulsion motor in gearless Azipod thruster is designed to last for the whole vessel’s lifetime. The drainage of possible water ingress to the motor module is secured by air overpressure. There was no traces of water leakage in the motor module and the motor was in excellent condition as it should be.
Strut & nozzle

The condition of strut and nozzle was very good as expected. After clearing out the sea growth there was no visible damages on strut or fractures in weldings.

Conclusion

Overhaul of the pod thrusters after abt. nine years in operation showed that condition of all critical components was found to be from good to excellent. None of the components showed signs of possible breakdown in foreseeable future.

Before the overhaul, the shaft seal was considered the bottle neck component for longer-term continuous operation. The original ABB recommendation in the design phase of pod thrusters for overhaul interval was five years. However, based on detailed findings from overhauled thrusters after up to nine years of operation, earlier findings after abt. six years of operation (Varis & Laakkonen 2011) and the fact that shaft seal design have been updated and improved further, overhaul recommendation of shaft seal can be extended significantly for DP operation.

Taken into account the excellent condition of other critical components as well: thrust and propeller bearing, slewing seal, slewing bearing, slewing gear and podded propulsion motor, Azipod CZ overhaul recommendation can be extended to 10 years for DP operations with continuous condition monitoring of the pod thruster.

References