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Failure analysis of a gear wheel of a marine azimuth thruster

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ABSTRACT

A failure analysis of two helical gear wheels of a ducted azimuth thruster is presented. The research work consisted of a fracture examination of the material in order to determine the damage root causes. The samples for the failure analysis were obtained from two broken teeth of two helical gear wheels. An analysis through the scanning electron microscope (SEM) was carried out close to the crack initiation. It was found that the damage in the bevel gears were by the fatigue fracture mode. The SEM analysis showed that the gear teeth were under severe contact stress during the operation aggravated by an inappropriate lubricating. A possible misalignment between the pinions and the gear wheels teeth could also contribute for the premature failure.

1. Introduction

Ducted azimuth thrusters [1] are currently used for propulsion system of AHTS (Anchor Handling/Tug/Supply) ships, namely cable laying and oceanographic researching, drilling vessels, etc. Nozzle propellers are also used in many types of ships for dynamic positioning of offshore platforms. Computational methods are currently developed in order to take exactly interaction between propellers and nozzles [2]. Ducted azimuth thrusters are generally used in seismic research ships. However there are dramatic differences between ducted azimuth thrusters units and conventional open propellers, namely the shape complexity of propellers, nozzles, gears case housing, stays, etc., which results in a strong hydrodynamic interaction between propellers and nozzles.

The present failure analysis is based on a vessel which propulsion system is obtained by three ducted azimuth thrusters, draw-up installation type, having each one a maximum continuing rating (input) of 1839 kW at 900 rpm. The ship where the damage occurred is a survey ship, being originally built as a cable layer vessel during 10 years. The azimuth thrusters have been overhauled because the vessel was converted for a new function. The total running hours of the three azimuth thrusters are about 20,000, being about 10,000 after the converting in the last two years.

Propellers of this vessel are of the controllable pitch type and each one of them is fitted in a duct, steering through 360° direction and with a Z-drive gear connection. The output propeller revolutions are about 270 rpm, and each one of azimuth thrusters is able to develop a bollard pull of approximately 30 tons under 100% of load. Both gearbox and clutch use a forced lubricating system, the oil flows to each bearing and bevel gears in the gearbox, being adjusted by the orifice in the lube oil manifold provided at the upper side of the gearbox.

Helical gears are extensively used in numerous engineering applications including gearboxes which are key components of machines. One of the most common causes of gear failure mode is due to tooth bending fatigue. The maximum tensile stress occurs at the root radius on the active flank of the gear tooth, while the maximum compressive stresses occur at

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