



## **GEAR FAILURE IN A MARINE STERNDRIVE UNIT – SINGLE EVENT OR WEAR AND TEAR?**

Broken gear teeth from the clutch mechanism of a marine sterndrive unit were analyzed and determined to be a result of long-term wear leading to fatigue cracking of the gear teeth. Analysis found no evidence of impact type damage or cracking to the gears or other drivetrain parts of the sterndrive to indicate failure initiated from a reported propeller strike. The gear tooth fractures were consistent with an end-of-life failure of the gear set.

### **SITUATION**

ESi was requested to determine the cause of a gear train failure in a marine sterndrive unit. It was reported that the sterndrive became stuck in gear, and that the malfunction was caused by a recent propeller strike. Teardown of the unit found metal fragments jamming the shift mechanism that originated from several broken gear teeth from the clutch gear assembly. ESi was requested to determine the failure mode and possible cause of the gear failure, and to provide a general condition assessment of the remaining components of the sterndrive unit.

**Practice:** Materials Science

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#### **Services Utilized**

- Metallurgical Analysis
- Metallography
- Scanning Electron Microscopy
- X-ray Energy Dispersive Spectroscopy
- Stereomicroscope
- Microhardness Testing

#### **About ESi**

For over 30 years, ESi has leveraged its multidisciplinary team of engineers, scientists, and professional technical staff to investigate many major accidents and disasters. Our technical expertise, hands-on experience and state-of-the-art facilities, combined with diagnostic, analytical and physical testing capabilities create an ideal environment for quickly identifying and interpreting the facts of a case.

#### **Contact ESi**

For more information visit our website or call us toll free at 866.596.3994

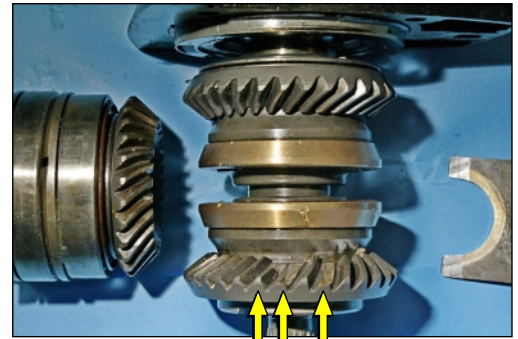
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## SOLUTION

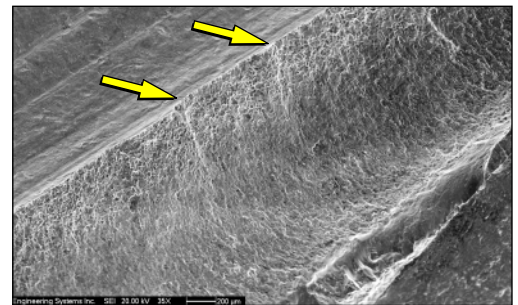
A teardown inspection of the sterndrive unit revealed three teeth on the lower clutch gear had fractured and the separated teeth were broken into various pieces, some of which jammed the shift mechanism. Each of the gear tooth fractures exhibited relatively smooth, transverse fracture surfaces exhibiting concentric beachmark features characteristic of fractures caused by high cycle fatigue crack propagation. The cracking had originated at the root radius on the load-side of the gear teeth, and was evidence of tooth bending fatigue. Examination of the fractures by optical stereomicroscope and scanning electron microscope (SEM) revealed transgranular fracture consistent with fatigue crack propagation. Small, parallel steps referred to as ratchet marks, were evident at the fracture origins that resulted from multiple, closely spaced fatigue crack initiation sites. There was no evidence of overstress cracks at the fracture origins, such as from impact loads induced by a propeller strike, that could be related to the initiation of fatigue cracking.

Other relevant evidence to the failure cause was the broad gear mesh contact pattern on the clutch and pinion gear teeth encompassing nearly the entire width of the gear teeth, indicative of extensive service. In addition, the face of several non-broken gear teeth exhibited areas of pitting and surface spalling that was characteristic of surface contact fatigue as results from long term wear.

Other than scrape marks on two of the propeller blades, other driveline components that typically show damage from a propeller strike showed no evidence of impact loading from such an event.



Clutch gear set – broken teeth on lower gear.



SEM photo of gear tooth fracture, showing ratchet marks at crack origin.

## RESULTS

Inspection and analysis of the submitted marine sterndrive unit revealed fracture of several gear teeth of the lower clutch gear. The gear teeth fractures were a result of fatigue cracking caused by high cycle bending stresses. Surface cracking and spalling observed on other gear teeth, characteristic of surface contact fatigue, and advanced overall wear to the gear set was evidence of long-term usage and indicative of an end-of-life failure of the gear set. The gear failure was not related to a single, high-load event such as a propeller strike.



Gear tooth fracture, showing beachmark features characteristic of high cycle fatigue.



Secondary gear tooth damage consistent with long-term wear.

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- Elastomers
- Electronics
- Building Materials



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