CASE STUDY

Ship Main Propulsion Reduction Gear Case History

Routine Vibration Analysis Avoids Catastrophic Failure

A ship's main propulsion reduction gear unit is a complex arrangement involving multiple gears and multiple shafts typically driven by twin turbines and powering a large diameter propeller shaft. Many US Navy ship classes and commercial vessels utilize up to four pieces of this type of equipment.

In September 2002, a routine pre-yard-availability, 400-machine MCA (machine condition analysis) survey was conducted on one of these ships by Azima DLI with assistance by ship's crew. A "moderate" intermediate shafting problem was identified in one of these units, based on an abnormally strong series of intermediate shaft rotational rate frequency harmonics. Ship's crew collected data again in November 2002 and the automatic diagnostic system produced a result of "serious" intermediate shafting problem. They tested again in early February 2003, immediately prior to arriving at the shipyard for a brief repair period. This result was "extreme" intermediate shafting problem. The trend was one of clearly increasing fault severity. Based only on these non-intrusive condition reports, the reduction gear was opened and inspected.

One of the high speed driven gears, associated with an intermediate shaft, was found to have a severe crack (about two and a half feet long) in the web. This gear, which is perhaps three feet in diameter, was replaced at the shipyard. A post-repair vibration test indicated good machine condition and no faults. It is speculated that if the inspection and repair had not occurred, then there likely would have been a catastrophic gearbox failure during subsequent ship operation. Such a failure would have necessitated the suspension of vessel operation for several weeks for the replacement of the entire gearbox. The latter repair requires the cutting of a major access area in the side of the ship.

The cost of removing one unit and installing a new unit is enormous, in addition to the actual cost of the replacement unit. From a couple of informal sources, it was estimated that the total cost saved in this case was upwards of eight to ten million dollars. This figure is approximately equal to the entire cost of the MCA program for the whole fleet of a dozen ships for a decade. Consider that the program is used to monitor more than 4,000 machines regularly, in most cases at least four times per year. Over time, hundreds of machines are given repair recommendations prior to machine failure. Equally important, most machines are proclaimed healthy and avoid the cost and risk associated with planned repairs using a predetermined schedule (time based maintenance). In view of this one case, it is easy to believe past studies which have shown the fleet MCA program to have a benefit-to-cost ratio in the vicinity of 20 to 1.

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Summary of Important Factors

- This model gear set is inherently quiet. Normal vibration levels are low.
- Vibration levels indicating a severe problem were too low to be heard or felt on site, particularly with the cacophony of sound and vibration from surrounding machinery.
- There was no indicator of a problem other than routine vibration testing as part of the MCA program.
- Detailed vibration spectral data (multiple axes and frequency ranges) allowed for specific diagnosis.
- It is believed that there was no plan to open the gearbox during the shipyard availability.
- This one example alone justified the multi ship MCA program for ten years.
- Replacing bearings or other smaller components before machine failure avoids much cost and operational downtime. For example, it is much less expensive to replace motor bearings than to replace the motor.
- Avoiding unnecessary repairs for thousands of machines saves a great deal of money. Furthermore, history shows many cases of machines being in worse mechanical condition after "repair" than before.
- Every one dollar spent on the MCA program saves the fleet operator approximately twenty dollars in unnecessary maintenance costs. The lower operational downtime can be invaluable.

Azima DLI Government Services

Azima DLI's Government Services stands as the product of over two decades of collaboration between the US Navy and our top notch engineering talent, resulting in the world's longest running and most effective condition monitoring programs.

Aircraft Carrier Machinery Condition Analysis (MCA)

The US Navy Aircraft carrier program began with DLI Engineering in the late 1970's and continues today. This program covers over 400 critical assets on each in-service aircraft carrier and has logged hundreds of thousands of tests providing benefit to cost ratios consistently in the better than 18:1 range.

Military Sealift Command Vibration Analysis Program

Azima DLI's program in support of the Military Sealift Command is the largest distance support vibration monitoring program in the world. The technology applied in this program serves as a model for industrial asset monitoring. Currently covering over 80 ships worldwide and 2000 individual machine tests a month, this program is an example of how expert system technology leverages available data review expertise to deliver highly efficient and reliable machinery monitoring information.

Guided Missile Destroyer Integrated Condition Monitoring System

In 2008 AzimaDLI brought together their best online monitoring products in combination with a cost saving portable instrument program to deliver a highly integrated shipboard monitoring program for the Navy's work horse DDG51 class guided missile destroyers. This custom developed solution integrates seamlessly with the shipboard control systems to monitor critical propulsions system equipment on a 24-7 basis and exercises logic to produce automated work orders as persistent machinery problems develop.