TECHNICAL PAPER

Diagnosing a Low-Speed Gearbox Problem

VIBRATION ANALYSIS AT WORK

Azima DLI was called on to help in the diagnosis of a suspected gearbox problem in a large plant connected with the paper industry. The gearbox in question had an input shaft with a 23-tooth pinion driving a large bull gear with 132 teeth which in turn drives another bull gear of the same size. The two gears are connected to large steel rollers about 24 inches in diameter. The two output gears turn at 52 RPM and the pinion turns at 302 RPM. See Figure 1 below.

The lubricating oil in the gearbox was regularly subjected to analysis, and the last report stated that there were iron particles in the oil. The maintenance supervisor asked if we could determine the source of the oil contamination. The first thing accomplished was to examine the vibration spectra measured near the bearings. The spectra looked normal, without evidence of bearing tones, so it was suspected that the metal was coming from one or more of the gears. See Figure 2, below. The problem then became to identify the faulty gear (if any), to allow the maintenance effort to proceed without delay.

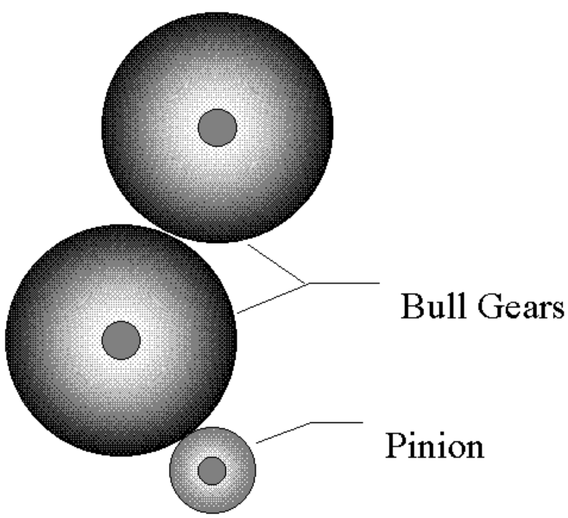


Figure 1

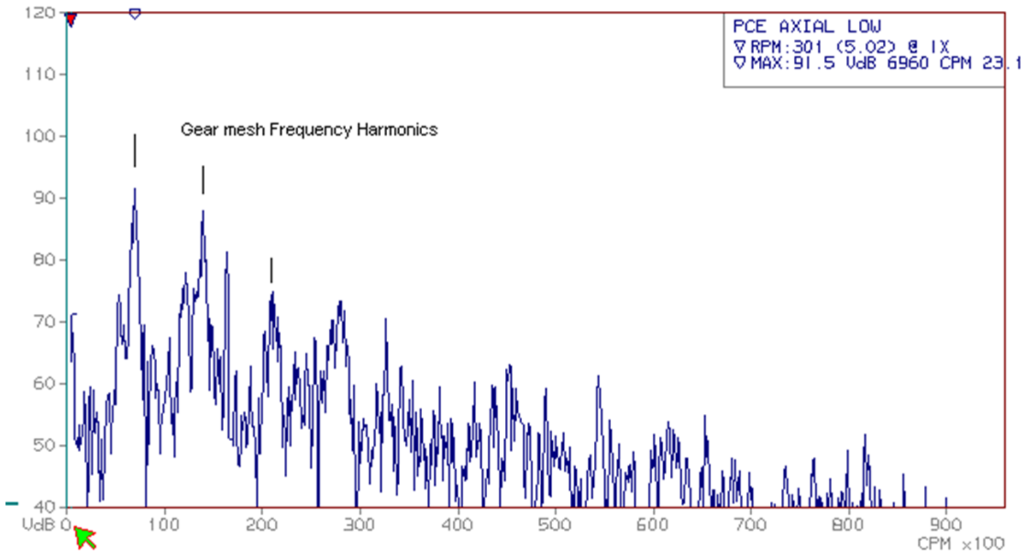


Figure 2

Synchronous averaging of time domain signals has been around for a long time, but has not been used nearly enough for machine problem diagnosis. Azima DLI's analyst decided to perform synchronous averaging of the gearbox vibration signature. This involves the use of a tachometer-derived synchronizing trigger in the vibration analyzer to collect of series of waveform samples that are averaged together. The important part of this is that the beginning of each time record must occur at exactly the same time in the rotation of the gear in question.

This allows the entire vibration signal that comes from the gear to be emphasized in the time domain average, and all the vibration components from the other gears, shaft rpm, and bearing tones, etc. to be averaged out. This produces a time waveform that shows the individual teeth on the gear, with very little contamination from other components from the machine. When doing synchronous averaging, the analysis parameters of the analyzer are adjusted so the time record length spans a little more time than one revolution on the gear. This is easily accomplished since the time record length (T) is the reciprocal of the FFT line spacing (DF) in the spectrum. It is simply a matter of choosing a frequency span and number of lines so 1/DF is longer than 1 divided by the gear speed in Hz. Of course, it is possible to look at the spectrum taken from a synchronized waveform, but this was not performed since the waveform provided the needed information.

When using synchronous averaging, the number of averages used must be quite large; usually in the vicinity of 100 or so. For the tests described here, the Azima DLI analyst used 90 averages. See Figure 3 for general time synchronous processing shown below.

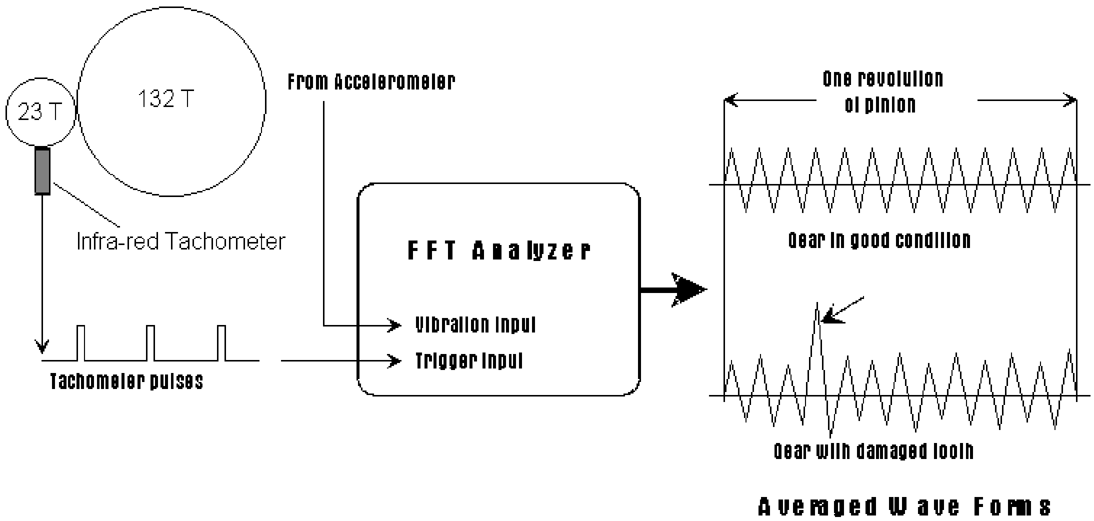


Figure 3

In many cases of synchronous averaging, the time record is much more interesting that the spectrum, since the spectrum contains no time information and the time domain shows any irregularities in the gear meshing. In this case, all the spectra were unremarkable, simply showing the gear mesh frequency and some harmonics.

When performing synchronous averaging on each of the two bull gears, there was no indication of any defect in the waveform. But, when performing the same test on the pinion, the waveform told another story. There was an obvious area on the gear where the meshing with the bull gear was very noisy and non-uniform. See Figure 4, below:

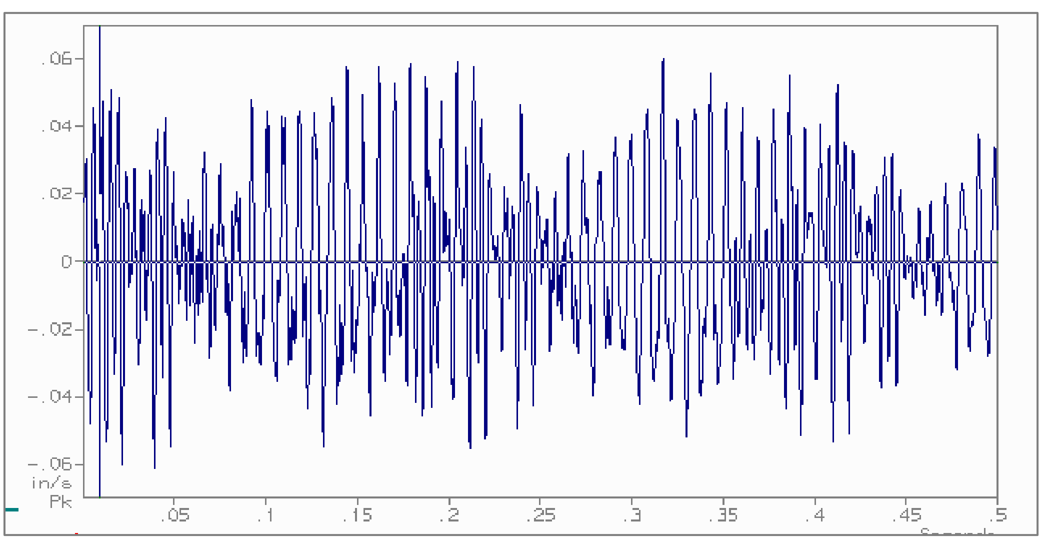


Figure 4

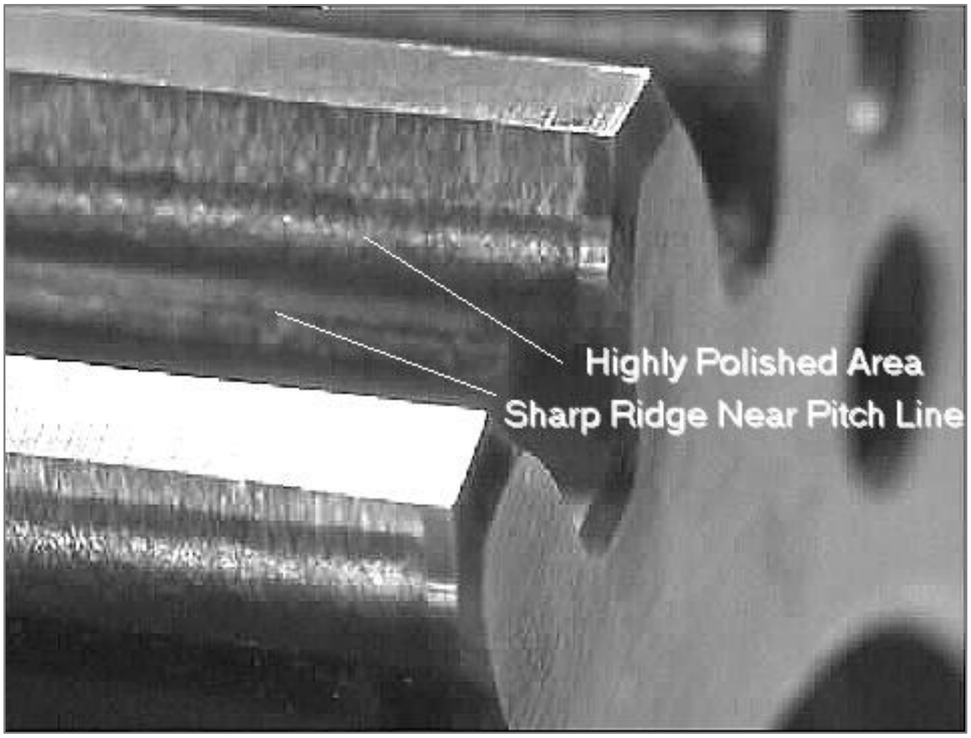
On looking at this data, Azima DLI called for an inspection of the gear. The maintenance chief was skeptical saying that gearboxes with more vibration that this one had run for 20 years without any problems. But at our insistence, an access plate was removed so Azima DLI could look at the gears. It was found that the keyway in the pinion shaft was badly worn such that the gear could be rotated back and forth on the shaft by about 1/2 tooth at the edge of the gear. There was also visible clearance between the shaft and the bore of the pinion. The bull gears showed no sign of damage.

Azima DLI contacted one of the engineers at the gearbox factory and described the situation. It was reported that the problem occurred during installation when the interference fit between the pinion and the shaft was too loose. It was recommended that the shaft and pinion be replaced immediately to avoid a catastrophic failure.

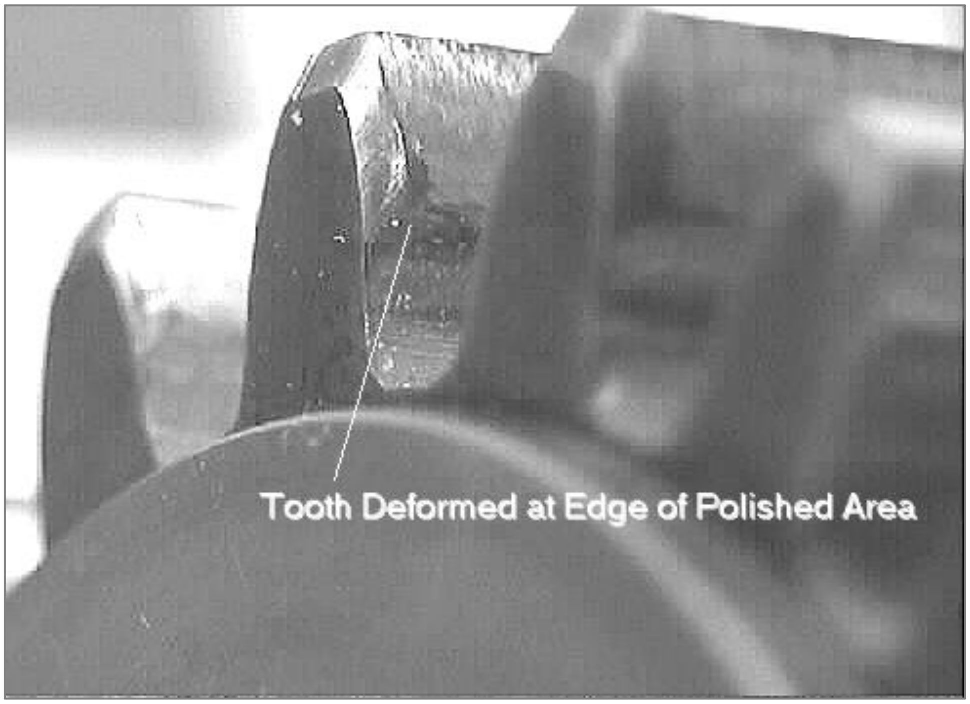
As mentioned earlier, synchronous averaging is not a new technique, but it seems to be seldom used in industry. It is not difficult and can result in vital information about a machine that is almost impossible to obtain any other way.

The following photos of the pinion illustrate the damage:

The figure above shows the spalling in the pinion bore caused by the gear turning back and forth on the shaft.



The figure above shows the abrading wear on the sides of the gear teeth.



The figure above is a close-up of the edge of a damaged tooth. Note the upset metal at the end of the contact area.

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Azima DLI is the leader and premier provider of predictive machine condition monitoring and analysis services that align with customers' high standards for reliability, availability and uptime. Azima DLI's WATCHMAN™ Solutions utilize flexible deployment models, proven diagnostic software and unmatched analytical expertise to deliver sustainable, scalable and cost-effective condition-based maintenance programs. The company's bundled offerings enable customers to choose comprehensive, proven programs that ensure asset availability and maximize productivity. Azima DLI is headquartered in Woburn, Massachusetts with offices across the U.S. and international representation in Asia-Pacific, Middle East, Central and South America, Europe and Australia.

To find out more about how we can help your organization keep your machines healthy and running, contact Azima DLI today.

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