Machinery Diagnostics Institute

Case Study: Broken Gear Tooth

Introduction

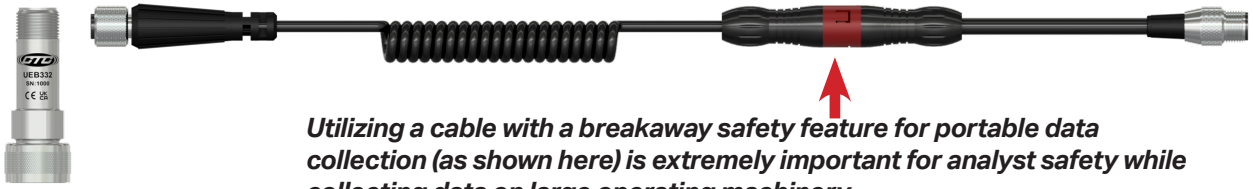
When it comes to gears, vibration analysis can be particularly effective in identifying broken teeth, which are one of the most common gear failures. Gears in good condition generate predictable vibration signatures during operation. These signatures are influenced by factors such as gear meshing, load distribution, and tooth engagement. However, when a gear tooth breaks or becomes damaged, the vibration pattern changes significantly.

Analysis

MDI was commissioned to perform routine data analysis at a Cement Plant. A broken gear tooth was found on a gear box.

MDI utilized the following hardware for this analysis:

- CTC's **UEB332** Dynamic Vibration and Ultrasound Accelerometer
- CTC's **MH136-1A** Flat Surface Magnetic Mounting Base
- CTC's **CB108-J2C-006-C555-SF** Emerson/CSI Compatible Cable and Connectors Assembly
- CSI 2130 Data Collector



Utilizing a cable with a breakaway safety feature for portable data collection (as shown here) is extremely important for analyst safety while collecting data on large operating machinery

CTC's UEB332 sensor was selected for routine analysis because of its ability to detect faults in both standard vibration ranges and within the ultrasound range. This makes it an extremely versatile tool for a wide variety of machinery, as it is capable of measuring frequencies from 30 - 1,380,000 CPM (0.5 Hz - 23 kHz) ±3dB.

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Analysis Procedures

1. Collect Baseline Vibration Data

It is essential to establish a baseline of normal gear vibration. This baseline data represents the healthy state of the gear system.

2. Identify Gear Mesh Frequencies

Gears produce specific vibration frequencies known as gear meshing frequencies. These frequencies correspond to the number of gear teeth and their rotational speeds. By analyzing the vibration spectrum, you can identify the primary gear meshing frequencies, which serve as reference points for gear tooth detection.

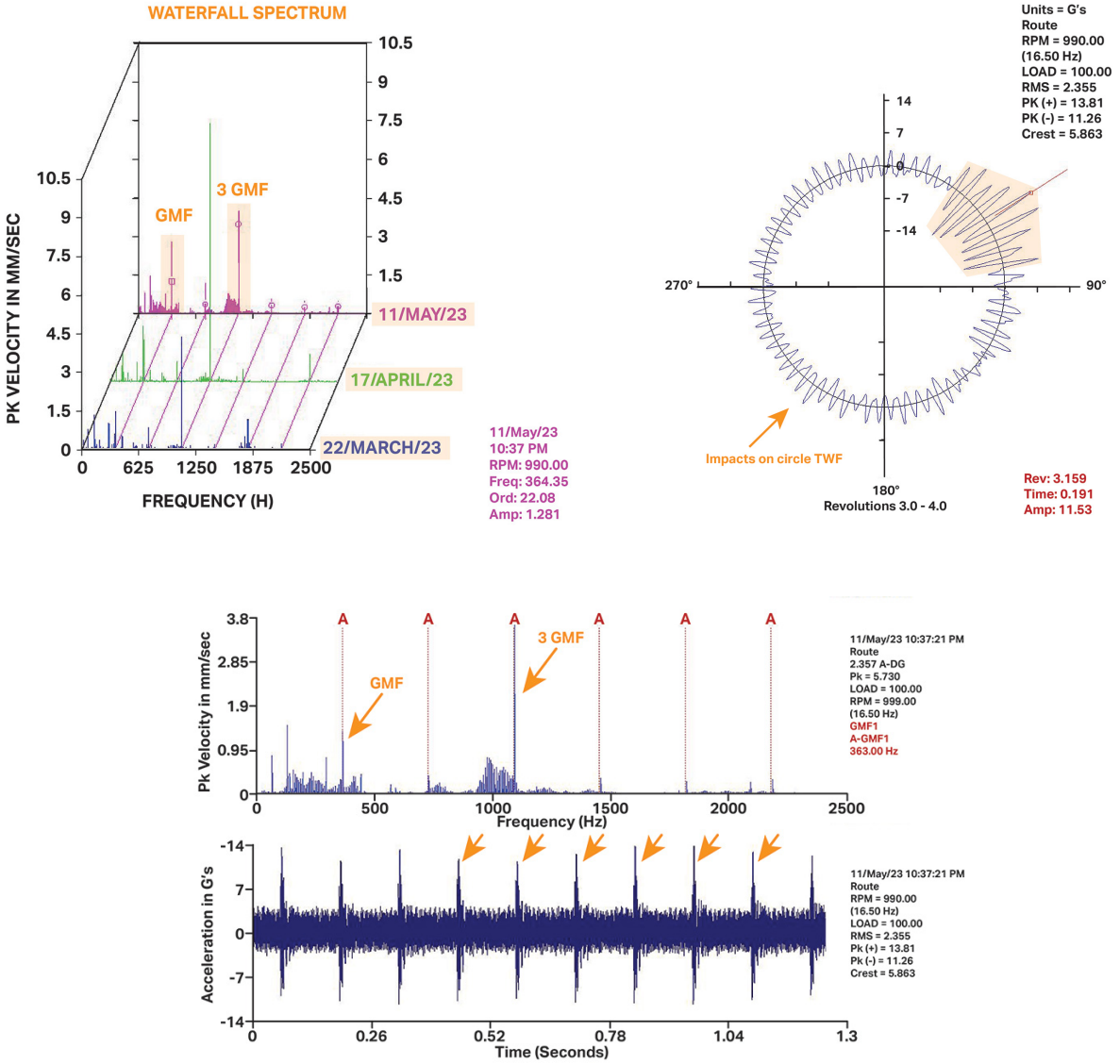
3. Monitor Changes in Vibration Spectrum

During regular gear operation, monitor the vibration spectrum using specialized equipment or vibration analysis software. Look for any significant changes in the spectrum, particularly around the gear meshing frequencies. Broken gear teeth often result in the appearance of new frequency components or alterations in the amplitude and phase of existing frequencies.

4. Analyze Sidebands and Harmonics

When a gear tooth breaks, it generates additional frequency components known as sidebands and harmonics. Sidebands are frequencies that appear along the primary gear meshing frequencies, whereas harmonics are integer multiples of these frequencies. Detecting the presence of sidebands and harmonics can be a strong indication of broken gear teeth.

Data Collected by MDI



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Conclusion

Through routine data collection, MDI was able to conclude that the spectrum is showing elevated vibration at the GMF component with harmonics, with a dominant 3rd harmonic, which is indicating gear wear and the component amplitude is increasing over time (shown in the waterfall plot on page 2).

The Time Waveform is also showing repeated impact with high amplitude, indicating a broken tooth. The customer was advised to do the following:

- Use the borescope to inspect the gears for symptoms of gear wear/broken teeth
- Perform GB lubrication fluid analysis (to check solid contamination and oxidation levels
- Perform GB wear debris analysis (to trend the gear wear condition)

Remember, early detection is the key to minimizing downtime and ensuring smooth operation of mechanical systems!