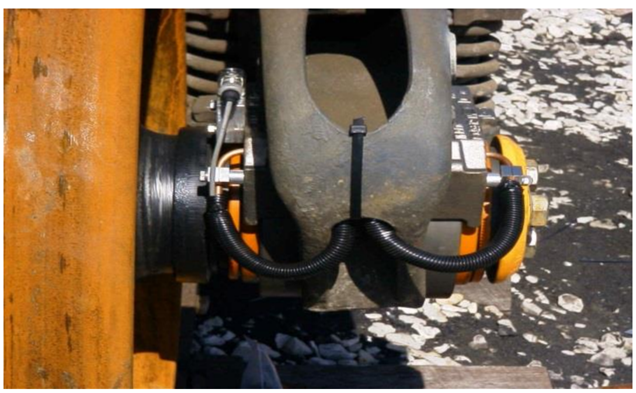
Vibration measurements in the rail industry

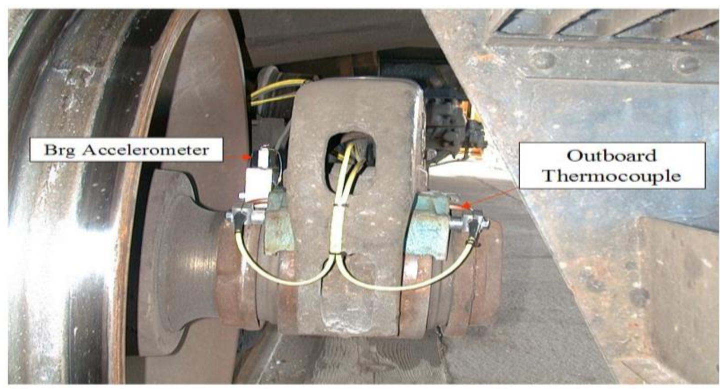
Applying predictive maintenance technologies to improve efficiency

Wilcoxon has a long history of working with the rail industry to improve detection of failed wheel bearings. Dating back as far as 2001, engineers at Wilcoxon have successfully demonstrated that commercial, off-the-shelf accelerometers can be used to monitor the state of wheel bearings under the grueling conditions presented by rail car wheels. Now, the use of vibration monitoring techniques can be applied to other locomotive parts to complement wheel measurements, making predictive maintenance programs more efficient and cost-effective.

Vibration monitoring has been used successfully for many years to assess the condition of rotating machinery in industrial settings. This same technology can be readily adapted to the rail industry and provide the locomotive engineer with real-time, condition-based information on the locomotive.



Wilcoxon model 787A mounted on the bearing adaptor of 100-ton coal car



Wilcoxon model 787A mounted on the bearing adaptor of a caboose

Existing tools, like hot bearing or dragging equipment detectors, have been available for a considerable length of time. Unlike vibration monitoring, these units detect components that have already failed. Dynamic locomotive vibration measurements record the operating condition of the locomotive during operation rather than wait for regulatory inspection times. Vibration sensors can monitor specific components, enabling early fault detection and helping maintenance engineers take action before failure. This results in a more effective use of downtime because component parts can be targeted for repair based on the increased knowledge of their operating characteristics, making failure less likely.

Where considerable time and attention have been given to developing a system for bogies and track monitoring, not enough effort has been devoted to monitoring the locomotive engine. If one looks at the components in a locomotive engine, it is easy to recognize equipment already proven to benefit from vibration monitoring.

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Main engine and generator

Starting with core components, most locomotives will have at the heart of its system a diesel engine capable of developing upwards of 3200 hp, over 8 times the horsepower of a high-performance automobile. The output of this prime mover is then coupled to a generator, capable of producing enough current to light approximately 1000 houses. In a locomotive engine, this power is directed to AC or DC drive motors on the trucks. On the trucks, each motor is coupled to the wheels through its own gearbox. This is exactly the type of capital equipment that should be monitored with vibration sensors if unexpected and costly breakdowns are to be avoided.

Taking a look at the feasibility of vibration measurements on the main engine and generator equipment, there are several components that fall within the realm of traditional vibration monitoring.

Diesel engine: Using a vibration sensor with a true peak detection circuit and an impact counter, the condition of reciprocating machinery can be tracked to identify developing mechanical faults.

Generator: Using loop powered 4-20 mA vibration sensors to accurately track the condition of rotating shafts is commonplace. By adding a vibration sensor to each end of a generator, both the drive end and opposite drive end can be monitored on a continuous basis to detect changes such as alignment and looseness.

Wheel drive motors: These units are typically equipped with roller element bearings. It is well documented that accelerometers detect roller element bearing wear long before actual failure, and by placing an accelerometer on both the inboard and outboard locations, time history information can be recorded. The earliest signs of wear will be seen in the high frequency energy output of the sensor. As wear progresses, the trend data can be monitored, enabling the engineer to schedule a motor rebuild at the appropriate time. For older DC drive motors, SCR condition can be determined by monitoring the SCR firing frequency amplitude. For newer AC drive units, accelerometers can be used to track the motor 1 x RPM without the need for separate speed sensors.

Gearboxes: Similar to cooling tower gearboxes, low frequency accelerometers can be used to capture the output shaft vibration. Equally important is the gear mesh frequency and its second and third harmonic, which can provide essential pre-failure information.

Head-end power unit

The main power generating hardware propels the train down the tracks, and a second diesel engine and generator may be a part of the locomotive. This second power house is used to power the rest of the train, such as air conditioners, lights and kitchen facilities on passenger trains. Obviously, these are critical components that need to function for the enjoyment of the rail passenger. The same accelerometer measurements can be used on the on the second engine and generator as on the main power house.

Trucks

Trucks hold the traction drive motors for the wheels and provide the suspension for the locomotive. The entire weight of the locomotive rests on these trucks. Large bearings connect the truck to the locomotive and allow it to pivot under the locomotive as it makes it way down the track. This is necessary for the train to be able to navigate turns. These large bearings can be effectively monitored using high frequency analysis techniques like those that are applied to roller element bearings. However, because these bearings are limited in their degree of rotation, high frequency ultrasonic accelerometers are used to best detect the condition of these units.

Cab

Although not directly tied to the operating performance of the locomotive, the cab presents the opportunity to measure the ride comfort of the engineer. By fitting three orthogonally mounted accelerometers on the seat suspension system, whole body vibration measurements can be made to determine the engineer's and fireman's vibration exposure in real-time.

Digital sensors

Digital sensors represent a recent advance in today's sensing technology that will enhance the benefits of vibration monitoring to the rail industry. Digital sensors convert the analog vibration signal to a digital signal inside the sensor housing and then transmit the digital vibration data, reducing the need for high sampling frequencies and reducing noise from nearby power equipment. Most importantly, the digital transmission of data can be compatible with existing platforms used in the rail industry such as ESRI's GIS Solutions (geographic information system). The running condition of locomotives is then available to the engineer on the train as well as the support and maintenance crews responsible for operating reliability in the rail industry.

Summary

The rail industry can benefit greatly from the proven best practice of vibration monitoring. The engine, truck, and cab can be effectively monitored with existing sensors that are commercially available. The result will be a reduction in failures, the ability to better schedule maintenance of critical operating equipment, increased efficiency, and cost savings.

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