The Vortok Measure and Detect Sensor

Train detection and condition monitoring of track and trains are essential parts of maintaining safety and reliability. Conventional track-based monitoring systems though, face many challenges; physical bulk, unfriendly connection systems, poor mounting techniques and fragility are the main problem areas.

The importance of good quality data cannot be overstated as this allows management decisions to be made and a good understanding of the duty cycles of rail fasteners, sleepers and vehicles allows proper design and maintenance plans to be instigated.

The new Vortok Measure & Detect sensor integrates three measuring technologies into a single compact, rugged device. Easily inserted into a single 10mm diameter hole in the rail web, the Measure & Detect sensor measures rail strain in either a vertical or horizontal plane, rail acceleration both vertically and laterally as well as rail core temperature.

By incorporating these elements into a single sensor body, the M&D sensor allows us to attach a number of applications which deliver benefit to both infrastructure and vehicle operators.

VORTOK measure and detect sensor

HISTORY

Originally developed by Roger West Laboratories for realtime weighing of road vehicles the Axload sensor began life as a single measurement device embedded into the axles of lorries in the UK.

Railways appeared an obvious development and the sensor body was further developed to incorporate a long nose which could place the strain sensor at the core of the rail. The benefits of this type of attachment to the rail were appreciated by Vortok Engineers who shared RWL's vision of incorporating additional sensing elements into the sensor body. The latest development from Vortok packs all of this technology into a neat, rugged stainless steel device which provides positive location for the solid-state sensing elements.

TECHNOLOGY

The result is a compact, rugged, general purpose device that can simultaneously sense a number of parameters. Each M&D sensor becomes part of the rail it is inserted into and measures:-

- Either vertical or horizontal strain in the rail (The sensor can be installed at 45 degree increments).
- Rail core temperature.
- Vertical acceleration.
- Lateral acceleration.

The M&D sensor uses a high quality instrumentation amplifier for the strain gauge allowing connections to be made near the sensor. The acceleration and temperature channels are both high level outputs that do not require amplification.

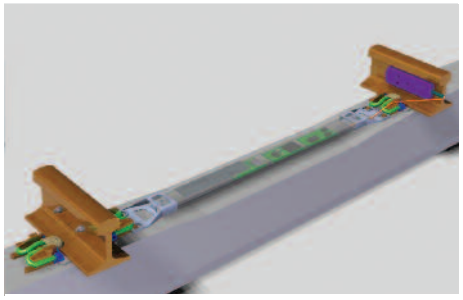
INSTALLATION

The M&D sensor is installed by simply drilling a 9.8mm hole in the rail at the neutral axis and then reaming to an H7 interference fit on the sensor's 10mm diameter barrel. Typically, the rail will be drilled with a Cembre type rail drill and the sensor can be pressed in at the desired alignment; a horizontal cable outlet indicates a vertical shear strain measurement while a 45 degree outlet allows the sensor to measure horizontal strain.

The M&D sensor can be installed in around 1/5 the time taken to install bonded (either adhesive or micro spot-weld) gauges. It is also immune to changes in environmental conditions such as rain and cold temperature. This removes risk and uncertainty from the installation process.

Taking advantage of modern low-power electronics and communication equipment the electronics required to interface between the sensors and the outside world can easily be fitted in to Vortok's balise beam technology. Combined with the quick to install sensors, this means that a complete monitoring installation can be complete in less than half an hour.

The M&D interface provides in excess of 1,000 volts isolation and can be battery powered for low speed logging situations such as rail strain monitoring.



VORTOK smart beam data acquisition unit

Currently the system uses a 3G wireless modem to transmit data but future developments will offer WiFi and short range RFID type interfaces so that railways in remote areas can use locomotives as a means of relaying data from monitoring systems.

DATA COLLECTION/ INTERPRETATION

Data acquisition depends upon application and can vary between measurements taken at intervals of minutes or hours for horizontal strain measurements up to measurement frequencies of 10kHz for Wheel flat detection. The M&D sensor is able to facilitate measurements up to speeds of 400km/h.

The M&D interface allows data collection up to 10,000 samples per second so that we can use it for production equipment and data gathering for future developments. The interaction between strain measurements and accelerations will be analysed at high speed to determine future uses for the M&D sensor.

The train above is interacting with the railway as it goes and the ability to monitor and understand this interaction allows optimal running of the railway in terms of performance, safety and reliability.

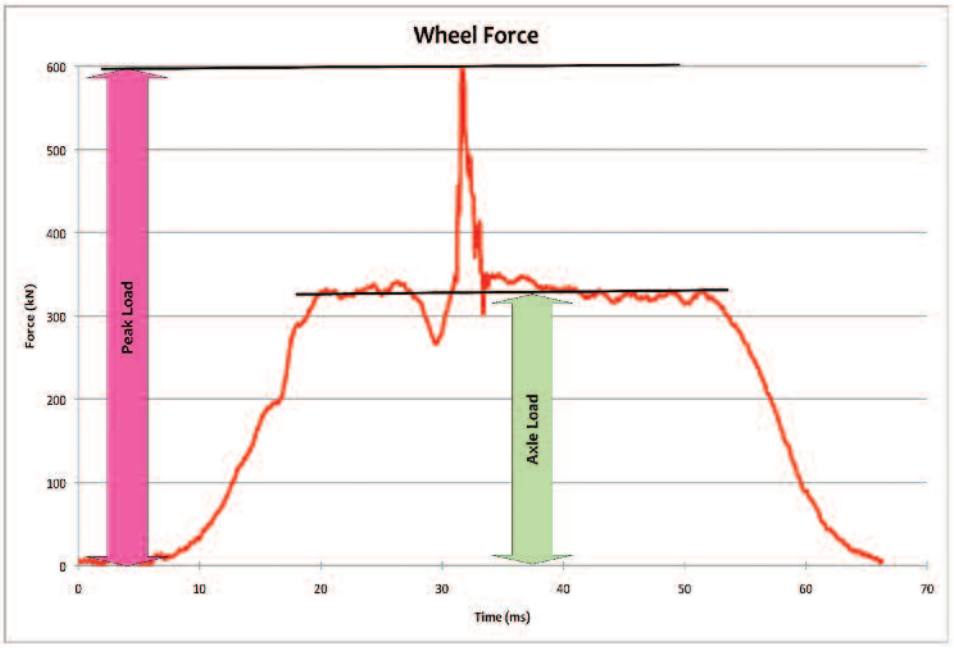
Low rail temperatures and wheel damage present a large risk of rail breaks

The data below is a small sample of data collected at very high speed. The red line shows the combined output from a pair of sensors as a train passes over an instrumented sleeper bay. The 'plateau' section of the blue trace is the axle load of the train and the spike is the additional force created by a wheel flat.

This small data trace represents three things; the axle load of the train, the condition of this particular wheel, and the presence of a wheel over this bay (axle counting). By taking the component traces from each sensor we can also determine train direction and the horizontal width of the red trace (with a known sleeper spacing) indicates train speed.

In the real world, each of those deduced parameters may have a different customer so any data analysis system needs to deal with this.

Temperature readings can tell us about the



tension and SFT in the rail plus it can help understanding of suitable impact limits at different times of the year.

The forces generated by this train (load and impact) plus the SFT of the rail and ambient temperature can determine the risk of the rail breaking or buckling underneath it

APPLICATIONS

VORTOK multi-sensor logger

Rail Stress Free Temperature

Vortok's extensive experience and reputation from marketing the VERSE SFT measurement system around the world provides an ideal cue to the development and marketing of a continuous Stress Free Temperature monitoring system. Many clients have expressed interest in continuous monitoring of SFT after the SFT has been established with VERSE.

By fitting an M&D sensor to the rail after the SFT readings are confirmed, the rail strain can be simultaneously tracked and recorded or transmitted to the client. The M&D logging system complements the M&D sensor and incorporates wireless technology so that data and alarms can be transmitted using the internet.

Demonstrations are planned for Autumn 2012 with Queensland Rail in Australia and CSX Corporation in the United States.

Axle Counting

As track circuits are phased out, axle counters have become an important way of detecting trains, their direction and speed. Typically, this is done with large magnetic devices bolted to the rail web. These sensors are prone to working loose and being damaged by rail grinding operations as they sit proud of the rail top. Additionally, they are susceptible to electromagnetic interference. The M&D sensor deals with all of these problems.

It is light, offering greater immunity to working loose. It is compact, giving better protection from grinding and tamping. Because the sensor measures physical train load it does not need setting up once in the rail and the sensor electronics are sealed within a cast body providing excellent electrical and environmental immunity. The M&D sensor is also immune to being triggered by other metal objects such as steel toecaps and track maintenance tools.

The M&D sensors' ability to work as an axle counter arises from its design as a vertical load sensor and wheel flat detector and is accomplished by positioning a pair of sensors at each end of a sleeper bay.

Train Weighing and Wheel Impact Detection

Weighbridges and impact detectors are common around railways all over the world. They can be used for measuring compliance to standards and also provide input to maintenance management systems. Sensor installation and maintenance are big issues for these systems and often require the railway to be closed for inconvenient periods for installation and maintenance.

The M&D sensor can provide major advantages in quicker and more reliable installation as well as greater reliability and availability of the system.

In addition to simplified installation the M&D sensor can provide enhancements to the data available from a typical site without increases in installation costs.

Accelerometers and temperature sensors within the M&D sensor allow monitoring systems to achieve greater probability of single-pass damage detection and will potentially allow systems to be built with fewer sensors. Lateral acceleration sensing using the built-in accelerometer will enable a multi-sensor equipped site to assist with collection of data for the analysis of bogie hunting problems and other train defects.

IN SUMMARY

The Vortok M&D sensor represents an exciting development for us and our industry. The widespread adoption of an easy-to-use sensor for the measurement and detection of important realtime data about the railway and our ability to understand and control it leads to a number of possibilities. n

Embedded strain sensors are used on Delta Rail's WheelChex system for Metro-North Railroad