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Timing Chain Testing
using the WaveBook™

Automotive

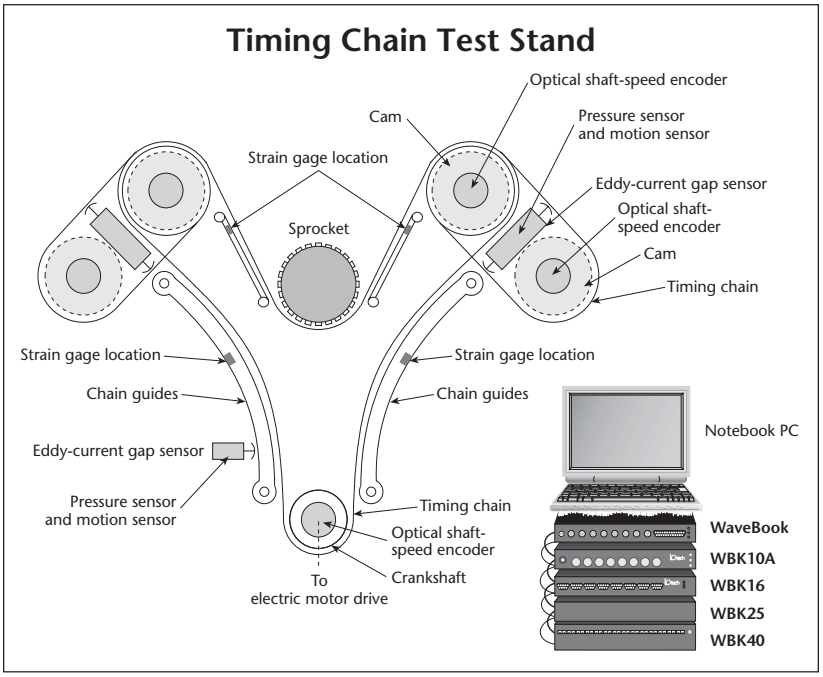
Application Note #76

Application Summary

One of the most critical factors in a gasoline engine that helps reduce harmful pollutants and maintain proper combustion is a precisely synchronized valve train. The timing chain connecting the crankshaft with one or more camshafts must maintain extraordinarily accurate dimensions over a wide range of speeds, accelerations, and temperatures to ensure proper valve positioning for intake and exhaust charges.

Modern timing chains have superior finishes and are manufactured with the finest materials and processes available for high reliability and low noise. To uphold that quality for each generation of automobile engine, the components of the cam drive system must be continuously tracked, controlled, and recorded. Components are evaluated for strength, wear elongation, elastic stretch, and plastic deformation. As a system, the cam drive is tested for load, temperature, strain, and motion.

U.S. Tsubaki, Inc., Chicopee, Mass., is one prominent company that designs and manufactures premium timing chain cam drive systems for major automobile engine manufacturers. The engines range from 1.5 to 5.5-liter displacement with in-line and V-cylinder configurations, and each requires a unique cam drive system. OEMs demand that the chain sprocket systems be extremely reliable, quiet, and maintain the highest timing accuracy possible over the life of the product. They depend on U.S. Tsubaki's expertise and customer satisfaction to provide them with the best cam drive system for their engine.



Several test stands in U.S. Tsubaki's test laboratory are instrumented and outfitted with chains, sprockets, tensioners, cams, and guides to simulate a number of different engine configurations. An electric motor drives the system to run product validation and life tests while an IOtech WaveBook records the data. The test stands are particularly useful when an engine is not yet available to be fitted with a timing chain system.

To ensure this quality, U.S. Tsubaki houses a modern testing facility devoted to product validation and life testing timing chain cam drive systems. The engineers record real-time data over long periods during reliability tests, both in their laboratory and at customers' sites.

Potential Solution

When the facility was first commissioned more than a decade ago, data acquisition systems in the test lab comprised digital oscilloscopes and digital-audio tapes. But this equipment is limited to only a few inputs and selectable acquisition rates, and the amount of data they can reasonably store is much less than that required for a comprehensive life test. What's worse, the software supplied with this equipment limits data presentation to a specific spreadsheet format with hardly enough power to sufficiently analyze the data.

IOtech's Solution

Recently, Neil Casey, Product Engineering Laboratory supervisor, evaluated several data acquisition systems with the goal of improving and updating the lab's capability to acquire, store, and analyze critical timing chain cam drive system performance. He needed to expand the number of input channels and acquire more accurate data that could be easily presented to internal and external customers in different formats. As a result, he purchased an IOtech WaveBook™. Casey is now able to keep pace with the changing demands of advanced product development and testing to rigid performance standards.

Frequently, when a new engine is not ready to be fit with an advanced chain cam drive system, Casey instruments a test stand simulator that basically mimics the engines' cam drive. The test stand contains sprockets, guides, and tensioners, all located exactly where they would be on that specific engine. An electric motor spins the system through the same speed range it would run in an actual vehicle. Says Casey, "During a long durability test, I use the WaveBook to measure, record, and stream data to a computer's hard disk drive. Also, I can look at the data in real time." Currently, Casey uses 16 analog channels, a WBK16™

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for 8 strain-gages, a WBK40™ for 14 thermocouples, and an Ethernet interface. Besides the channel flexibility, he appreciates the ability to select any acquisition speed he desires. "With the oscilloscopes, we had limited selection of preset acquisition rates. That meant capturing enormous amounts of unnecessary data or not capturing enough data to accurately evaluate a system. I typically run 2.5 times the acquisition speed needed, so we don't run into aliasing problems, and the software allows me to set it," says Casey.

The WaveBook records motion, pressure, force, strain, temperature, and vibration. Eddy-current gap sensors measure the motion of the hydraulic tensioner's plunger. Pressure transducers measure oil pressure at the hydraulic tensioners and at specific points in the engine.

A load cell measures the force that the tensioner exerts on the pivot lever. "This provides us with an estimate of the load on a running chain, which is key to predicting the life of the system," says Casey: "We don't want to overload the cam drive system and break it or decrease its usable life. We have tight design specifications to meet its expected life, and the WaveBook verifies that we do not exceed its limits."

Strain gages applied to the fixed guides and the pivot guides measure stress. Thermocouples measure the oil temperature at various points throughout the oil circuit and engine, specifically near the hydraulic tensioners.

Theoretically, timing chain cam drive systems comprise a rigid system, but one side is in tension while the other has slack. This extremely small differential could introduce timing variations between the crankshaft and camshaft or from cam to cam. An optical shaft encoder placed on the crankshaft and each camshaft measures torsional vibrations and the resulting timing variations between them.

"I like the WaveBook's flexibility," says Casey, "and its small, compact physical size. I like the selectable capture frequency, and how quickly we can set it up and start taking data. Also, it's very easy to learn and use. The portability lets me take it to the customers' site."

Casey says the DASYLab® software is excellent for scaling, post-processing, creating charts and reports, and generating the schematic layout on the screen that engineers can use to build a test sequence. And it's easy to revert to a user screen for less technical savvy operators. He also likes the graphic interface, the user interface, the ability to route channels in any order and scale them differently. "The file format is particularly important for my customers. We work with many automakers and the various engineering groups work in different file formats. With WaveView, I select only the file format they typically use."

Conclusion

U.S. Tsubaki designs and manufactures premium timing chain cam drive systems for several leading automobile makers. To ensure high quality, specialists conduct durability and life tests in its on-site test lab using an IOtech WaveBook and signal conditioners for measuring strain, temperature, and numerous other variables.

WaveBook Series

The WaveBook™ series of portable and desktop digitizers offer multi-channel waveform acquisition and analysis for portable or laboratory applications. All WaveBook models include 8 built-in channels expandable up to 72 channels of voltage, accelerometer, microphone, strain gage, thermocouple, position encoder, frequency, high voltage, and other signal types. For applications beyond 72 channels, up to four WaveBooks can be combined within one measurement system, for a total capacity of 288 channels. WaveBooks are available with an Ethernet connection to a PC.

Features

- PC connection via Ethernet
- 1 µs/channel scanning of any combination of channels
- Expandable up to 288 high-speed channels
- SYNC connection allows multiple units to measure synchronously
- Add up to 224 lower-speed thermocouple channels
- DSP-based design provides real-time digital calibration on all channels
- Single and multichannel analog triggering with programmable level and slope
- Digital TTL-level and pattern triggering
- Pulse trigger and external clock
- Programmable pre- and post-trigger sampling rates
- Sixteen 1-MHz digital inputs
- Operable from AC line, a 10 to 30 VDC source, such as a car battery, or optional compact rechargeable battery module

Included Software

- WaveView™ for *Out-of-the-Box*™ setup, acquisition, and real-time display*:*
  - Scope mode for real-time waveform display
  - Logger mode for continuous streaming to disk
- eZ-Analyst™ for real-time spectrum analysis
- Export data in third-party formats
- Includes drivers for Visual Basic®, Delphi™, C++ for Windows®; DASYLab®, and LabVIEW®
- ActiveX/COM development tools