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Biomechanical Impact Testing
using the LogBook/300

Acceleration Measurement

Application Note #81

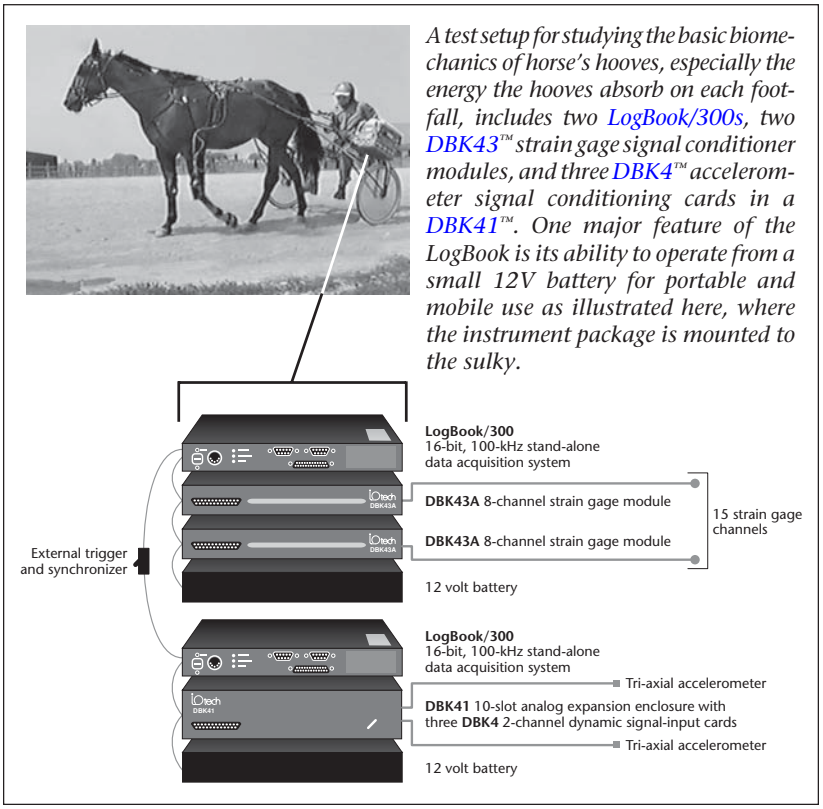
Application Summary

Owners and trainers of racing Standardbreds and Thoroughbreds have long speculated about the efficacy of shoeing their horses. Moreover, even when shod, the question inevitably arises, what are the best types of shoes that should be used? The advantage or disadvantage of using mild steel, aluminum, composites, or no shoe at all shouldn't have to be a debatable issue, claims Jeff Thomason, Professor of Biomedical Sciences, University of Guelph, Ontario, Canada. After all, the main intent of a shoe is to protect the horse's hooves and limbs from injury.

In order to gather scientific data on shod and unshod horses and offer proof for choosing one approach over the other for a specific situation, Thomason investigated the basic biomechanics of horse's hooves. He wanted to measure the energy hooves absorbed each time they hit the ground. And for a fast racehorse, that could happen 150 times in a minute.

Potential Solution

Thomason's first data acquisition system consisted of force plates, strain gages, and two eight-channel data loggers initially designed and built at the university.



A test setup for studying the basic biomechanics of horse's hooves, especially the energy the hooves absorb on each footfall, includes two LogBook/300s, two DBK43™ strain gage signal conditioner modules, and three DBK4™ accelerometer signal conditioning cards in a DBK41™. One major feature of the LogBook is its ability to operate from a small 12V battery for portable and mobile use as illustrated here, where the instrument package is mounted to the sulky.

The first test setup included a Standardbred horse and sulky. Strain gages were glued to the hooves with the lead wires dressed along the animal's legs and run to the data logger mounted on the sulky.

Initial testing revealed some advantage to using shoes, but strain gages alone connected to data loggers capable of only a relatively low sampling rate and limited capacity prevented capturing high frequency, shock-pulse information. Accelerometers and data loggers with sample rates of 10 kHz to 60 kHz were needed for more comprehensive data collection.

IOtech's Solution

Thomason evaluated the LogBook/300™ with IOtech strain gage and accelerometer signal conditioning modules and found the system more than adequate. The LogBook's high data-sampling rate was a primary consideration, but the small size and modular concept was also a critical factor because the equipment has to be carried by the horse and rider when the experiments don't involve a sulky. "We had no problem setting up the new IOtech data acquisition system. All the components came with proper documentation and cables, and it worked straightaway out of the box," says Thomason. "There was a bit of a learning curve regarding set up and use, but that was not an issue."

Thomason assembled a test bed consisting of up to six accelerometer and 15 strain gage channels connected to two LogBooks. One was programmed to collect the accelerometry at 15 kHz per channel, the other to collect strain at 5 kHz. When only one triaxial accelerometer was used, the sample rate was boosted to 30 kHz/channel, and to 60 kHz if only the channel with the largest signal was recorded. The accelerometers were mounted on small hexagonal base plates, and the strain gages were glued directly to the hooves.

"The equipment certainly gave repeatable results, and that's a good benchmark for reliability," says Thomason. He did some bench testing in the lab using 1000-g accelerometers and reported that the test, which was intended to simulate the actual racecourse conditions to confirm calibration, was a little more difficult than initially envisioned, but the results were consistent. "And the actual test results vary predictably," says Thomason, "depending upon what the animals are running on, from hard surfaces to soft." Now, with the LogBook/300, Thomason can collect data faster and set up as many channels as are needed to carry out a specific experiment with any combination of strain gages and accelerometers.

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The LogBook recorded acceleration signals on a number of different shoes, and the results were similar, but the unshod horses recorded peak accelerations that were about 25% higher than the shod horses. On impact there was a 2.5 ms transient that reached 800g for some footfalls, and averaged over 400g. Also, the data revealed a high frequency component in the unshod horse that was not found in the shod horse, which could potentially cause some harm. "This observation is somewhat counter-intuitive," says Thomason, "since the high stiffness of the shoe wouldn't seem to have much of a damping effect. But it definitely appears to."

Some people argue that shoes are bad for horse's hooves, because they don't allow the hooves to expand and contract under load, which they normally do. Hooves visibly deform when under full load, and the shoe would obviously tend to restrict that. On the other hand, some say that when the animal is slamming its hoof into the ground without any kind of protection against impact or abrasion, the potential for damage comes in other ways. "But this is sort of a trade-off," says Thomason, "and we would like to offer our research findings as to whether certain types of shoes, or no shoes at all, are good or bad."

Other academics also are studying the biomechanics of horse's hooves. But there aren't many such specialists in the field. "Now, with the help of the LogBook and time-tested software, we can make the results more user friendly and meaningful to more people working in the horse industry. The original data export program was written for the custom-made data logger and it was limited, because we used only a principle strain reduction routine," says Thomason. Now he uses the IOtech software to view both acceleration and strain gage data, and LabVIEW® and MATLAB® software for post processing and analysis.

Thomason's two general aims in his continuing program of research are to understand more about the biomechanics of the hoof in an academic sense, how the biological structure behaves, and he intends to deliver practical information to people working with horses so they can better understand common problems and help prevent injuries such as lameness. These are two side-by-side issues, but they have different demands.

In addition, Thomason will conduct a project next year to investigate how acceleration, stress, and strain affect the hoof over time, and correlate that data with changes in growth patterns of the hooves. And that will involve the IOtech equipment in multiple tests on the same horse over a 7 to 8 month period.

Conclusion

At the University of Guelph, Ontario, Canada, both shod and unshod racehorses are outfitted with strain gages and accelerometers to measure forces, the energy absorbed, and the deflection of their hooves when running at top speed. The measurements are necessary to gather data, which will help trainers and owners find ways to prevent some of the more common injuries that racehorses sustain, such as lameness and fractured or broken limbs.

LogBook

The LogBook™ combines on-board intelligence and a large capacity PC-Card removable memory, with the industry's easiest and most powerful data logging software. Its 16-bit, 100-kHz A/D and triggering capabilities make it ideal for collecting high *and* low speed phenomena. A comprehensive array of signal conditioning expansion cards and modules are offered that allow the LogBook to take measurements from virtually any transducer, from thermocouples to accelerometers.

Features

- Operates without a PC at the test site
- 16-bit, 100-kHz analog and digital sampling
- Compact yet expandable architecture can accommodate over 400 channels of analog, digital, and frequency I/O
- Stand-alone nonvolatile storage of over 250 million samples via removable PC-Card memory
- Card swapping and uploading during acquisition allows continuous data acquisition
- Communication with PC via RS-232, parallel port, modem, or by transporting a PC-Card; optional RS-422 interface
- Built-in analog inputs support 14 programmable ranges up to 20V
- Synchronous, mixed signal acquisition of analog, digital, and counter inputs
- Optional modem support provides remote communication
- Optional GPS support (LogBook/360 only) logs location information
- Optional control terminal provides channel inspection, and acquisition queries
- AC or DC powerable

Software

- Includes LogView™ *Out-of-the-Box*™ software for easy setup, calibration, and more; no programming required
- Simple spreadsheet-style interface provides powerful setup features for immediate startup
- Acquisition configurations can be transported to the LogBook via PC-Card, serial port, parallel port, or modem connection
- Provides direct support for a wide variety of transducers
- Includes eZ-PostView™ for post-acquisition data viewing