

Dyno Velo Cycling Power Meter



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VPG's Micro-Measurements brand strain gages are used in cycling applications to measure the amount of torque produced by a cyclist while riding. Using Micro-Measurements' Advanced Sensors, Dyno Velo was able to develop a one-of-a-kind "removable torque transducer," which can be mounted by friction within the hollow spindle of a modern bicycle crank. The challenge in building the torque transducer was to achieve the required performance at an acceptable cost. Although elegant in its simplicity, the transducer design was technically challenging.

Company/Institute: www.dynovelo.com

Industry/Application Area: Torque Measurement

Product Used:

- Advanced Sensors, next-generation Strain Gage
- M-Bond 610, 600

The Challenge

Power meters have been gaining in popularity among cyclists as an important tool in providing training feedback. They are used for tracking improvements in a cyclist's fitness — for training and for racing, especially in time trials and triathlons. One of the major challenges in producing a transducer for cycling applications is the potential temperature variation during the course of a ride in contrast to typical industrial applications where the temperature tends to remain constant. Additionally, power meters have typically been rather expensive, and in order to control costs the transducer must be mass-produced. Driven by the need for cost reduction, Dyno Velo set out to produce a transducer that could be installed by a local bike shop or even by an experienced home bike mechanic. Due to the temperature variations the transducer would encounter, Dyno Velo needed to develop a sensor that would be less sensitive to temperature, or set the sensor output to be much more sensitive to torque than to thermal effects. In the end, a combination of both was selected, where the design of the transducer increased the sensor's output using a next-generation strain gage, and the sensor's thermal sensitivity could be calibrated in the field.



The Solution

To measure the power generated by a cyclist, Dyno Velo developed a unique transducer to measure the crank spindle's torque from the left leg during cycling, so as to convert the torsion-based output to units of power exerted during the pedaling process. One of the challenges in the transducer design was that bending loads could exceed the shear load (torque) in the spindle. As is well known in gage design, bending loads are normally cancelled when using a standard shear gage pattern in a Wheatstone bridge for measuring torque. However, with Dyno Velo's transducer design, the diameter and length of the shaft are on the same magnitude as the gage itself, and a standard shear gage design does not fully cancel the bending loads. Thus, a custom torsion gage having a high manufacturing tolerance was needed to solve the problem.

Working with VPG's Micro-Measurement group, a custom gage was built cost-effectively, with the tight tolerances required and with low power consumption (a requirement dictated by battery power). Also of great importance was the desire to reduce, if not completely eliminate, the effects of day-to-day temperature changes on the power meter's accuracy. Through the expertise of VPG's engineers and their white papers on strain gage technology, Dyno Velo engineers were able to augment their work using x-ray imaging and scanning electron microscopy to isolate and decouple metallurgical and mechanical issues from thermal issues, and to identify other variables compounding the temperature effects.

For example, solder junctions proved to be one of the variables causing thermal effects. Great care was taken to produce solder junctions of uniform size in production, especially when the process was automated. Additionally, each conductor used for the inter-bridge connections between the gage and the remaining circuit was made of equal length, and the grid alignment was optimized per the gage markings to assure the Advanced Sensors strain gages generated the maximum output possible.



The User Explains

To capture a cyclist's performance, the placement of a power meter is critical for capturing the maximum output signal that is being generated during each crank revolution. Locations such as the bottom bracket, crank arm, rear hub, pedals, and even the frame have been entertained as solutions. As with any concept, there are pros and cons to each of these methods. Based on historical data, the crank system provides the ideal location for capturing the peak-to-peak response during pedaling. But the question of where exactly is the best place in the crank area to capture the output has created a variety of solutions. Many power meters are designed for the professional cyclist, where the high cost is justified for the training and performance increases. Any new power meter design needs to perform well enough to at least match the performance of these devices, but at a price point significantly lower for a broader range of cyclists.

The crank spindle was chosen as the ideal location for placement, as a measurement in the spindle could be reduced to a simple torque measurement. This simplified the power measurement and guaranteed performance. The hollow space within the crank spindle not only provides natural protection for the sensor, but it also eliminates mechanical interference issues with the frame and other components.

Perhaps one of the most important considerations for this design is future product growth. Forbes has grouped cyclists into four categories, as found at <http://www.forbes.com/sites/michelinemaynard/2013/08/27/whos-out-there-on-the-roads-the-4-types-of-cyclists/>.

Based on this and other market studies, it has been found that well over 70% of those who ride are not "performance" cyclists. Therefore, the majority of cyclists are simply not interested in a power meter. However, Dyno Velo found that a large percentage of cyclists are interested in a product that would improve their riding by indicating when to shift for mechanical derailleurs, and were interested in an automatic shifter for electronic derailleurs (patent pending). For professional cyclists, there was little to no interest in such a product.

Dyno Velo therefore decided to develop an aftermarket torque sensor as a standalone building block for OEM crank manufacturers to add to their existing cranks with as little modification as possible. This approach does not require manufacturers to directly add a power meter (torque sensor) to the crank, but allows the power meter (or other future shifting products) to be sold and serviced later by the local bicycle store. This mimics the sale of other aftermarket bicycle products such as speedometers, which are always added later to the bicycle, but do not require modifying the bicycle or its components. [Click on this hyperlink to watch a short video](#) that gives a fine glimpse of the Dyno Velo power meter and torque transducer in its final installation.



“With Micro-Measurements’ Advanced Sensors strain gages; we were able to develop a one-of-a-kind removable torque transducer, which can be mounted by friction within the hollow spindle of a modern bicycle crank”

Acknowledgement:

Last but not least, Dyno Velo would like to thank Donielle Dockery and Gilad Yaron both of Micro-Measurements for their immeasurable guidance and support in this project as well as Texas Instruments (analog-to-digital convertor), and Alotech LLC (metallurgical analysis).

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