Brake Rotor Testing Using Capacitance Sensors

Introduction

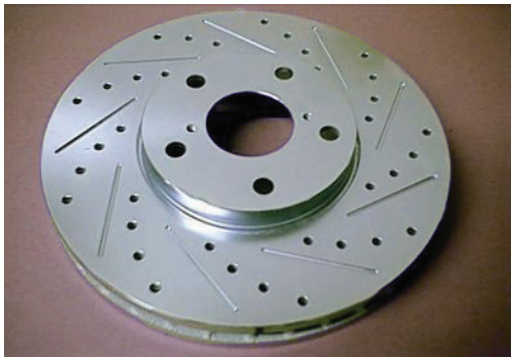

Figure 1

As we venture onto our highways we hardly give much thought to the operation or complexity of our vehicle braking system. We only think about it when we have to suddenly slam on the brakes to avoid an impending catastrophe. At that instant we hope and pray our car will stop in time for our safety, and the safety of others. Most don't realize the extensive design and testing that goes into braking systems to insure we stop in time.

Take the brake rotor for example (see figure 1). Under normal operating conditions it is subjected to extreme temperatures and forces, which causes rotor distortion and possible failures. To make certain it can withstand these conditions, extensive laboratory testing is performed to refine the design for longevity, short stopping distance and vibration free operation. Production lines are equipped with inspection equipment to provide 100% assurance that poor quality products are not used. Extensive on-vehicle testing is done under real life conditions to test prototype units and engineering designs. Test vehicles are driven for long periods of time while brake performance is monitored by a variety of sensors and data acquisition systems.

For efficiency reasons brake rotors are becoming lighter, thinner and designed with cooling vents to improve performance. These changes continue to reduce the braking surface, forcing designers to consider alternative materials and designs. This is where MTI Instruments (MTII) comes in.

The Driving Test

In order to simulate what a driver encounters on a daily basis, test vehicles are equipped with both displacement and temperature sensors to actively monitor the brake rotor. Data on disk runout, disk thickness variation (DTV), disk "coning" (warpage), and temperature are continuously collected and monitored from inside the vehicle. A combination of city, country and highway driving courses are set up along with many designated braking locations to fully simulate in days what a driver typically experiences in weeks or even months. This information is used so that brake designers can determine how long a braking system will operate and its overall performance. Once a design is proven, mass production begins.

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The Problem

Figure 2

No brake rotor is perfect. Inconsistencies in manufacturing processes introduce thickness variation and runout. It is important to identify these conditions prior to installation in a vehicle. In order to accomplish this, dynamic measurements of the rotor are required on the production line. Conventional non-contact capacitance displacement sensors are used to monitor the distance between the probe and the rotor while spinning. Unfortunately, rotating targets frequently have an intermittent, uncertain or nonexistent ground path which causes inaccuracies in typical capacitance sensors.

The Solution

MTII offers a unique "Push/Pull" Capacitance sensor (see Figure 2) which eliminates the need to electrically ground the rotor. This novel approach uses two sensing elements built into one probe body that work together to complete the measurement circuit. The push/pull probe design provides a clean and consistent electrical path resulting in decreased noise, higher accuracy and significantly more stable and repeatable measurements.

The Results

Tests were performed to compare the results of a standard capacitance probe to that of MTII's Push/Pull technology. As the rotor was rotated, the output of each sensor was captured on an oscilloscope and is presented in Figure 3. Clearly it can be seen that the Push Pull technology provides a much cleaner and more accurate output signal.

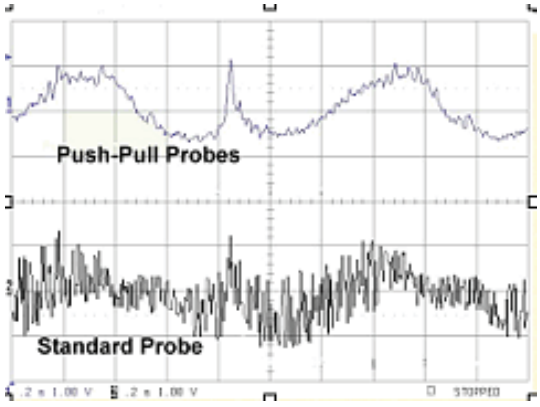

Figure 3

MTII's newest Multi-Channel brake rotor measurement system, the Accumeasure™ 500 (see Figure 4) provides up to 6 independent measurement channels in a rugged, compact amplifier package. It provides the manufacturer the ability to measure thickness in 3 separate areas along the brake rotor radius "on the fly". The AS-500 can operate on 12 Vdc power for in-vehicle testing and its compact design is ideal for installation into small, confined spaces. The amplifiers are specifically designed to be protected from shorts caused by the probe contacting the brake rotor or from contaminants such as water or oil.

Figure 4

Based on the push/pull advantages, several major Japanese and Korean vehicle manufacturers have standardized on MTII's Accumeasure sensors for their testing requirements. In addition to brake testing MTII's sensors have been used in demanding applications such as spindle and shaft runout, engine vibration, thermal expansion and contraction, suspension travel and fuel injector motion, to name a few. If you have a challenging noncontact measurement application, contact MTII's experienced Application Engineers for more details on laser, capacitance and fiber-optic sensors. With over 50 years of product line history MTII will provide a practical, cost effective solution to meet or exceed your requirements.

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