Noncontact Displacement Sensors in Automotive Manufacture

Advances in noncontact displacement sensors are bringing new levels of quality and efficiency to the research labs and assembly lines of automakers worldwide.

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Over the past decade, breakthroughs in sensor technology have improved the automobile both inside and out. Most consumers are aware of the benefits that sensors have contributed to automotive subsystems such as air bags, automatic braking systems, and load leveling systems.

Less obvious is the increasing role of sensors in R&D, QC, and manufacturing methods that are being driven by automakers' outsourcing certain subassemblies to Tier 1 suppliers such as Robert Bosch, Delphi, Visteon, and Continental Teves. These companies now supply complete suspensions, wheels, brakes, transmissions, and other components to Toyota, DaimlerChrysler, GM, Ford, and Volkswagen, among other global manufacturers. The automakers' role has also changed over the years from vertically integrated manufacturer to major assembly houses. Tier 1 suppliers are therefore subject to very stringent quality system requirements such as Q1 and QA9000, which place emphasis on building high-quality parts the first time, every time. As new QC practices such as in-process and 100% parts inspection become more commonplace, capacitive noncontact displacement and thin gap sensors are being used in an increasing number of locations throughout the automotive manufacturing process (see Figure 1).

As component and subassembly dimensions shrink, the sensors used to measure them must also undergo miniaturization. Displacement sensors, for example, often must fit into locations with diameters <1 mm, where they measure gaps as small as 0.009 in. (0.23 mm). Other requirements include:

- Operating temperatures to 1832°F (1000°C)
- Overall diameter reduced to 0.004 in. (100 microns)
- Accuracy to 8 µin. (0.2 microns)
- Immunity to magnetic fields
- Response up to 200 kHz
- On-vehicle DC modular electronics

Braking Systems (Disc and Drum)

The rugged modular electronics in Capacitec's new line of disc brake wear analysis sensors (see Figure 2) are capable of taking high-temperature (932°F, 500°C)

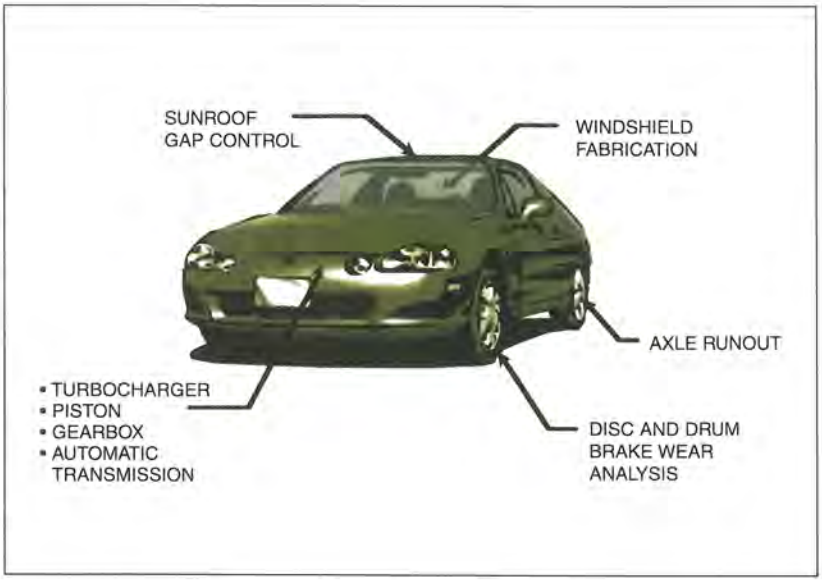

Figure 1. From engine piston and valve design, to braking and suspension system testing, noncontact displacement and gap measurement systems help engineers design better cars and trucks.

vant to an understanding of piston assembly complex dynamics.

Vehicle Assembly

Consistent and precise measurement of the various gaps around a vehicle's exterior surface is a difficult problem because of the wide variety of gap locations, each with its own requirements. The variables include:

- Different materials to be measured (e.g., metal, rubber, composites)
- Various contact/noncontact requirements (prevention of scratches)
- Wide range of gap sizes (0.23–10 mm)
- Wide range of target geometry (e.g., flat to radius, radius to sharp edge)
- Signal processing differences
- Instrument portability

Based on its experience in the aircraft industry, where smooth exterior surfaces are crucial to proper aerodynamics, safety, noise control, and fuel economy, Capacitec has developed a number of both contact and noncontact gap and flushness sensors for this application. The former are often preferable for target materials that are nonconductive or have unusual shapes; the latter are used when both sides of the target materials are conductive or where there is concern about finished surfaces, such as the painted exterior of vehicles at the end of the production line.

Controlling the flushness between a mounting bracket and the glass in an automobile sunroof is a good example. The curvature of the sunroof necessitates a varying amount of adhesive between the glass and the bracket. The way the process works is that the glass is first positioned into a fixture incorporating eight sensors around the sunroof. The sensors control the amount of epoxy distributed between the glass and bracket, ensuring a consistent geometry to each sunroof. This gap and flushness measurement system allowed General Motors to achieve a ±0.004 in. (100 micron) tolerance on a gap of 0.060 in. (1.5 mm). The finished sunroofs were flush against the top of the vehicle, dramatically reducing noise while contributing to aerodynamics and fuel economy. ■

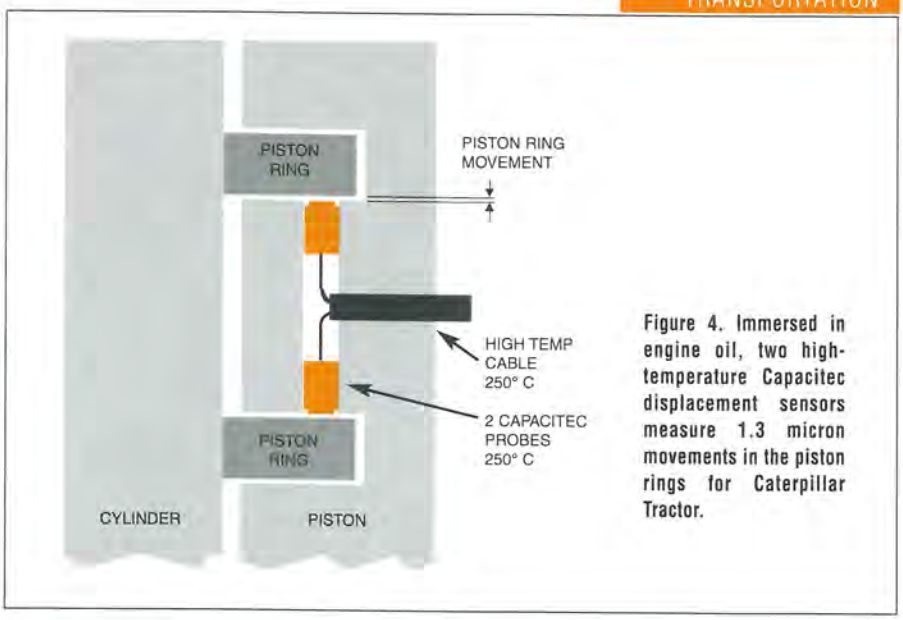

Figure 4. Immersed in engine oil, two high-temperature Capacitec displacement sensors measure 1.3 micron movements in the piston rings for Caterpillar Tractor.

Figure 5. Two differential (back to back) noncontact sensors mounted in a 1.5 mm thick assembly are looking at the underside of two thin leaf springs that in turn contact a gap space with a range of 1.5–5.0 mm. Since there are two opposed spring forces, the wand assembly self-centers itself in the gap, almost doubling the measurement range of previous configurations.

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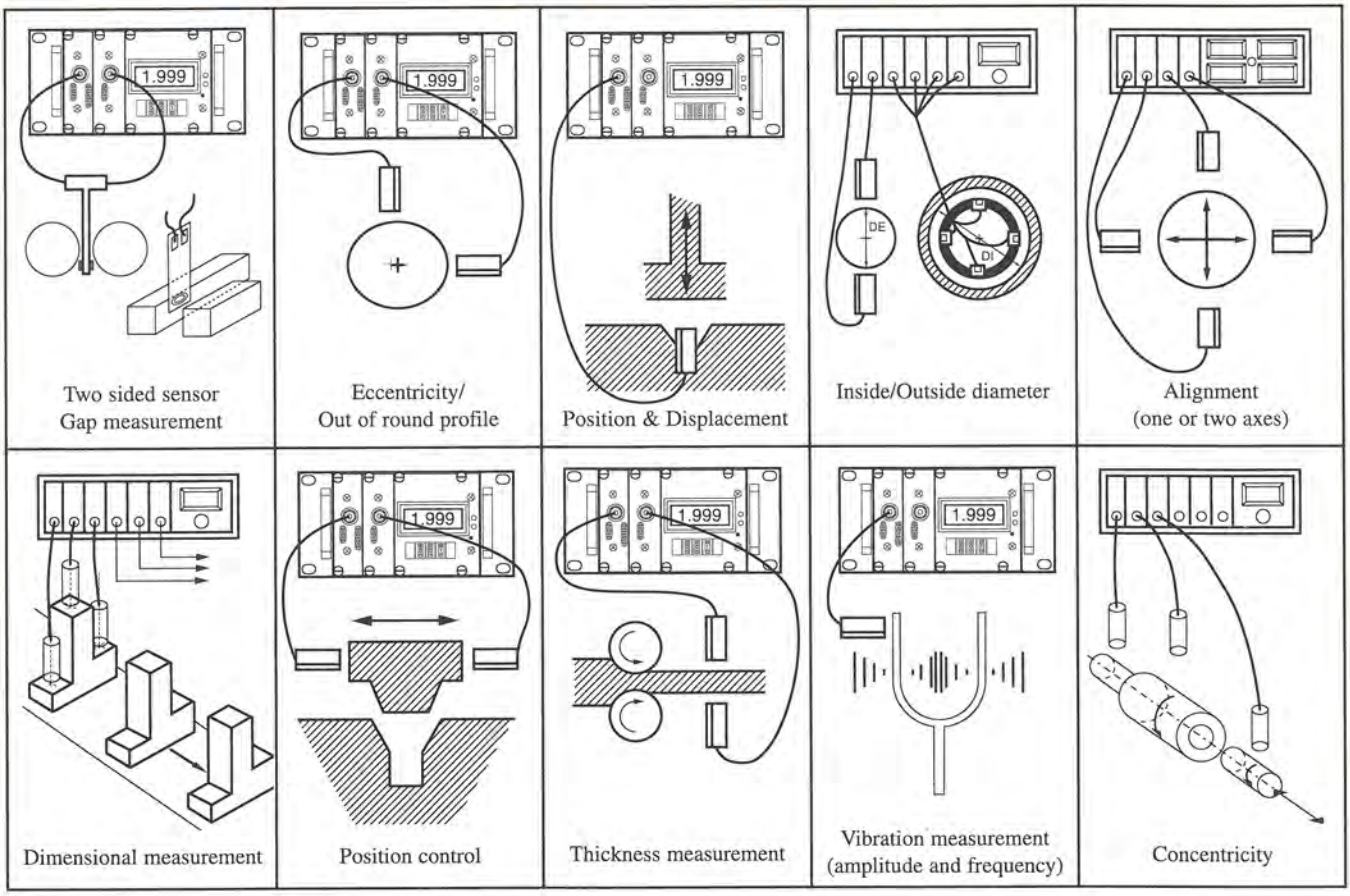
TYPICAL APPLICATIONS



Two sided sensor
Gap measurement

Eccentricity/
Out of round profile

Position & Displacement

Inside/Outside diameter

Alignment
(one or two axes)

Dimensional measurement

Position control

Thickness measurement

Vibration measurement
(amplitude and frequency)

Concentricity

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