Filling the gap

THE GAPMAN GEN3 ELECTRONIC GAP MEASUREMENT SYSTEM FOR AIRCRAFT APPLICATIONS HAS HIGHER RESOLUTION, LONGER BATTERY LIFE, AND AN EASIER-TO-USE INTERFACE THAN ITS PREDECESSOR

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For years aircraft assembly and structural component manufacturers have been using traditional contact methods (plastic shims, feeler gauges, and step gauges) to measure gaps during production and final assembly of commercial and military aircraft.

Hundreds of gaps between metal/metal, metal/carbon fiber reinforced polymer (CFRP) and CFRP/CFRP surfaces must be measured and controlled during production to determine whether liquid or solid shimming is required. These gaps can be found in a variety of applications throughout the aircraft structure, from the front passenger doors to the vertical stabilizer. Figure 1 shows typical applications.

Control drives gap measurement

Due to increased standardization of process improvement methods such as SPC and Six Sigma, aircraft structural component manufacturers from Alenia to Lockheed are adjusting output specifications from their measurement instrument suppliers.

The new standards require the measurement, data capture, and documentation of an ever-increasing number of physical measurements, such as gaps, holes, and parallelism in their manufacturing and assembly processes. Traditional gap measurement methods, such as feeler gauges and plastic shims, cannot meet the new quality specs for accuracy and repeatability and are not able to automatically record and store error-free data.

Engineers have also found limitations and major reliability problems with these old methods. Shims and feeler gauge suffer from inadequate accuracy. Plastic shims can vary in thickness by 7.6μm and both these and feeler gauges cannot meet required operator-to-operator repeatability levels. In addition, accuracy is reduced over time due to shim wear from constant rubbing against hard surfaces, which can also cause damage to the target surfaces.

It is now common for these users to perform analysis of variance (ANOVA) between groups and gauge repeatability and reproducibility studies (Gauge R&Rs) to compare the capability of traditional measurement methods versus more modern methods, such as digital capacitive non-contact gap sensor instruments. A leading aircraft structure manufacturer recently tested and concluded that feeler gauges could not meet their Six Sigma requirements. Specifically, their Gauge R&R concluded that mechanical gauges totaled 45% measurement dispersion versus 20% or better for Capacitec gap gauges. Since feeler gauges showed a measurement dispersion of greater than the required 30% minimum for Six Sigma, they were forced to change. The solution was to use Gapman's capacitive gap measurement system, known as the electronic feeler gauge.

Sensor selection

The capacitive gap sensor wand model selection is application-driven and is chosen in reference to the following factors: minimum gap, gap range, target material combinations (metal/metal, metal/CFRP, CFRP/CFRP), difficulty of access to target, and so on. There are dozens of standard models of flexible wands and spring contact sabres along with the option of developing custom models according to customer needs.

Flexible wands

Kapton flexible wands are typically used to measure the thinnest gaps where the flexibility of the wand improves accessibility to the target. The thinnest gap measurement available can be found in Model GPD-(3X1)I-A-225, which offers a range from 0.15mm (0.006in) to 1mm (0.0394in). The popular Model GPD-4.5 (.0075)-A-250 has a range of 0.2mm (0.0075in) to 3mm (0.118in). Other models can be specified to have a range up to 10mm (0.394in)

Spring contact wands are typically used in applications where one or both targets are non-conductive, a target size is less than 2mm, or

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Left: Gapman Gen3 with flexible gap sensor wand

the surface or shape of the target is irregular. These are also the most popular choice for CFRP/CFRP applications where the minimum gap is greater than 0.64mm (0.025in). The Spring Contact wand Model GPD-5 (0.22)-A-150 has a range of 0.64mm (0.025in) to 3mm (0.118in) and the range of the GPD-10 (.034)-A-350 is 0.86mm (0.034in) to 10mm (0.394in).

For larger gaps such as the gaps between trailing edge flaps and the wing where the gaps typically run 20mm ±5mm, a custom wand can be offered. In this case a non-contact or spring contact wand is built onto a 15mm shim with a set of GPD-10 sensors giving a range of 15- 25mm.

The selection of integral or remote wand mounting configuration to the Gapman is according to customer preference.

Gapman Gen2

The Gapman Gen2 model was introduced with flexible wands in 1996. The remote versus integral configuration and availability of spring contact wands were introduced later. Today, most commercial and military aircraft manufacturers worldwide use the Capacitec Gapman Gen2 to measure and control gaps that typically range from 0.2-3mm (0.0078-0.118in). In the assembly of tail sections, a Gapman Gen2 with flexible wand is used to measure gaps 20cm (7.87in) inside the subassembly. A flexible wand can also be used for difficult-to-access targets.

The self-grounded spring contact sabre is often used to measure gaps between targets where one or both sides are composed of CFRP. In another application example, gap readings from the Gapman Gen2 are sent to a CNC machine, which manufactures custom shims that fit perfectly in the void between two structural components of the aircraft.

Gapman Gen3

The Gapman Gen3 was introduced in late 2010. Among the main design enhancements of the next-generation Gapman Gen3 are higher resolution output (0.00001in/0.254µm) with +/0.5% FS (12.7µm) typical accuracy with a GPD-5F wand; 10,000+ datapoint logging and storage capabilities; battery life doubled (now 22 hours minimum with 3AA lithium batteries); simplified PC user interface software to allow control of the outside button functions and storage of gap measurement data through USB or Zigbee wireless transfer.

With a compact form factor measuring just 56 x 220 x 28mm (2.2 x 8.7 x 1.1in) and weighing less than 1 lb (454g), the Gapman Gen3 features the same high-precision dual capacitive sensing technologies for position-compensated measurements as its predecessor, with components housed in a factory-floor-tested, highly rugged enclosure. Using standard and custom sensor probes that are backward compatible, Gapman Gen3 enables easy insertion into gaps as thin as 0.150mm (0.006in).

The Gapman Gen3 records and stores datapoints for easy transfer to SPC, in support of Six Sigma and other quality systems. Other next-generation enhancements include a bright blue alphanumeric Active Matrix OLED display; external menu selection buttons for millimeters/inches; a calibration button, to adjust to the standard of a known gap; and inclusion of an industry-standard USB Type A combination data output and external power port. With its user-friendly design enhancements, the Gapman Gen3 can be used to effectively measure gaps within a wider range of aircraft applications, including aircraft manufacturing and assembly operations, metal and rigid composite surfaces (CFRP), and aircraft engine build and rebuild. Other applications include flexible solar panel lamination, coater roller-to-roller parallelism, film production, and any other non-contact gap measurement application characterized by minimal gap tolerances and complex assemblies. ∎

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