Gapman Gen3

GAP MEASUREMENT SYSTEM

The Gapman Gen3 is in the final approval stage at several major European aircraft manufacturing plants. The plants are performing final assembly and producing large components for the next-generation aircraft platforms that will launch over the next few years

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Gapman Gen3 technology was introduced in the March 2011 issue of *Aerospace Testing International* in an article entitled *Filling the Gap*. The article covered the Gapman Gen3 electronic gap measurement system for aircraft applications with higher resolution, longer battery life, and an extremely easy-to-use operator interface.

In the commercial aircraft designs currently in process, there are new standards required for gap measurement accuracy, data capture, and documentation of the shimming (packer) process. The applications where thousands of gaps are measured are found in more complex aero structures. There is also a considerably higher proportion of structural and skin components made from carbon-fiber reinforced polymer (CFRP). Difficult-to-access gaps, tapered gaps, and hidden gaps also raise the bar for the choice of the best gap measurement solution.

Several sites in Europe have performed Gauge R&R and ANOVA testing on the Gapman Gen3. Typically in these tests, three different operators measure a minimum number of different target material types of well-defined locations with successive repeat trials (three tries is typical). The individual results are tabulated, yielding a score that indicates the measurement variance of production measurement methods. The target material combinations in the tests includes aluminum/aluminum, aluminum/CFRP, titanium/CFRP, and CFRP/CFRP. The Gapman Gen3 has passed these rigorous tests at at least six sites.

Aircraft gap measurement and shimming applications

The most critical application where repeatable gap measurements are required in aircraft assembly is during the packer and shim selection process. Liquid and solid shimming is necessary during the fabrication of aircraft components such as the wing and fuselage

The very flexible non-contact gap measurement wand

"The shimming process is also critical during the production of an aircraft's fuselage sections"

sections as well as during final assembly of aircraft.

By using the traditional precision metal feeler gauge method of measuring tapered or uneven gaps, manufacturers are significantly handicapped in identifying the actual true gap topology in any given shimming location. Remember that the 'feel' in feeler gauges represents a minimum gap.

In wing production, the outside aircraft skin is attached to ribs and spars. Due to variable dimensional tolerances, and partially as a result of the stiffness of the CFRP, the two mating surfaces do not perfectly match. This creates voids between the CFRP or metal surfaces. To enhance structural integrity and retain aerodynamic design, these voids must be filled with shims. A liquid shimming technique is used for smaller voids, while solid shims are typically used to fill voids of more than 0.6mm.

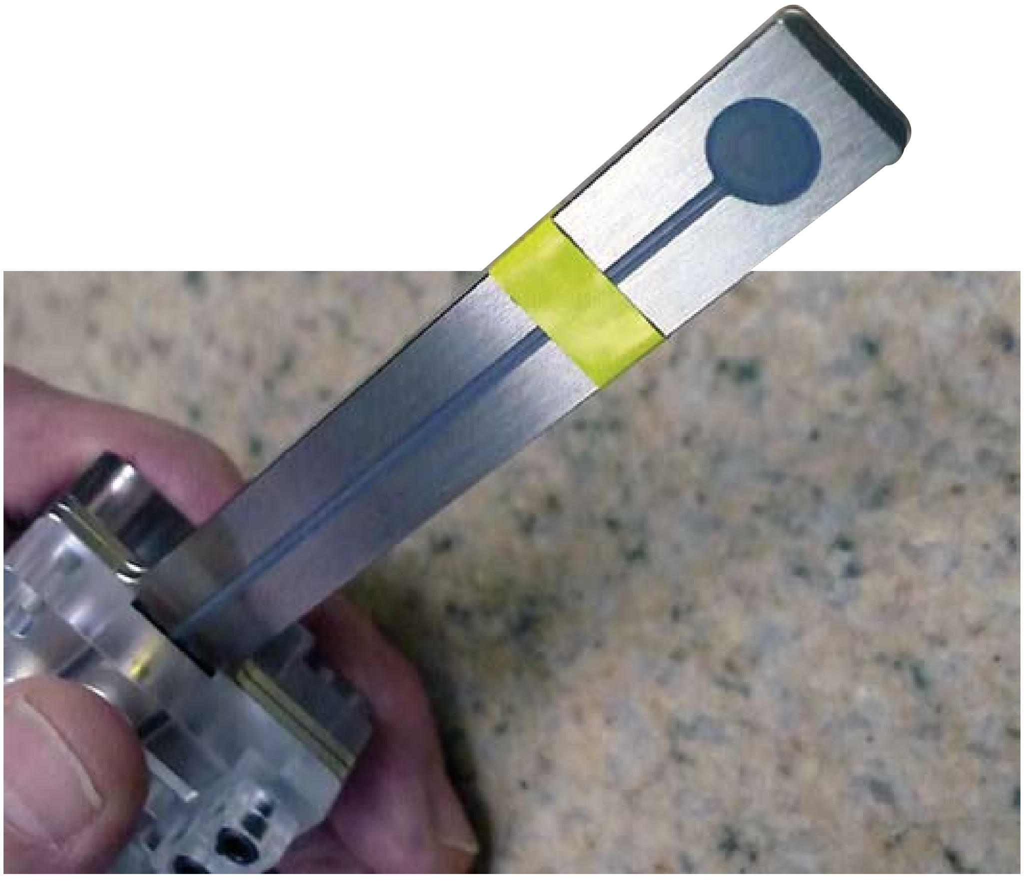
The shimming process can be very time-consuming due to the combination of gap measurement, gap data collection and transfer and selection of standard shims. Filling larger and more complicated shaped voids can require custom-machined shims that add significantly more time to aircraft production, especially if this process is performed using manual methods.

The Gapman Gen3 is popular among aircraft manufacturers worldwide due to the multiple hours of repeat labor saved using the 'electronic feeler gauge', with its built-in data collector and a wireless option that provides more direct measurement data transfer (see Figure 1 for typical aircraft gap measurement applications).

Below are some specific examples of gap measurement requirements on the latest aircraft designs.

Aircraft main wings

New wing designs use CFRP on the upper and lower outer skins to provide enhanced aerodynamics and lower weight, contributing to the improved fuel efficiency of the aircraft. The skins are attached to ribs, spars, spar joint plates, hinge ribs and L brackets made



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from a variety of materials including CFRP, titanium, and aluminum alloys. Depending on the aircraft size, the gaps measured range from 0.2-3.5mm.

Studies have shown that using a Gapman Gen3 versus precision metal shims has reduced the shimming process by a factor of four. This is a significant time saving considering the thousands of gap measurements taken during the shimming process of the wing assembly. These huge time savings contribute to very favorable returns on investment for aircraft producers.

Vertical stabilizer

The fabrication method of a vertical tailplane (VTP) has similarities to that of an aircraft’s main wings. From start to finish, this component requires a few thousand gaps to be measured during the shimming process. Often, the VTP shell is manufactured horizontally, making gap measurement and shimming more practical.

Typical gaps in assembly of VTP shells are between the outer skins (now using CFRP material) to the shell, ribs and spars fabricated in CFRP, titanium, and other metals. Gaps in this application can range from 200 microns to 4mm. The gaps are mostly flat, but some are tapered.

Fuselage sections

The shimming process is also critical during the production of an aircraft’s fuselage sections. Repeatable gap measurements are required here in applications of filling voids between a variety of connecting surfaces such as the outer skins, stringers, panels and splints. Materials are similar to those used in wings, and gaps run from 200 microns to 3mm.

There are also many difficult to access gap locations such as behind the splints, where a measurement wand must be flexed to 90°. The very flexible sensor wand of the standard Gapman Gen3 has been found to be an ideal solution in this application (see Figure 2).

Engine pylons

Another application in which gap measurements are required is during engine pylon production. These gaps are located between the pylon and an assembly of engine ribs positioned into a reference on a bench fixture. About 30 gap measurements are taken around the jig to ensure that the outer shape dimension matches the specification. The materials here are titanium and steel. The typical gap range is 3.5-6mm. Based on the requirements of this application, a rigid thicker sabre is used in conjunction with a Gapman Gen3.

Final assembly applications

The most critical fastener applications in aircraft production are during final assembly. The join between the main wing assembly and the center wing box is critical as these junctions undergo significant stress during flight. This holds true for the rear portion of the aircraft as well, which includes the horizontal and vertical stabilizers. These locations by design can use very large shims to match where these surfaces meet.

The body of large aircraft can be assembled in barrel-like radial sections or longitudinal half or quarter sections. These are jointed together in a critical seaming operation. These joint sections need to be fastened and bonded together using unique processes that require a large number of gap measurements. This is a highly stressed area of the aircraft and needs special attention in locations several centimeters inboard near fastener locations. ∎

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