Shimming process

BRYAN MANNING

RE-FILLING THE GAP

One company states that optimized Gapman reduces cost in aircraft CFRP shimming process

BY ROBERT FOSTER AND BRYAN MANNING

"TO DATE THE GAPMAN GEN3 HAS ACHIEVED A GAP MEASUREMENT/SHIMMING OPERATION SCHEDULE FIVE TIMES FASTER THAN THE FEELER GAUGES"

In the March 2011 issue of *Aerospace Testing International* an article entitled Filling the Gap introduced the Capacitec Gapman Gen3 technology. It covered the Gapman Gen3 portable electronic gap measurement system for aircraft applications, which has replaced the feeler gauge method at all major commercial aircraft manufacturers worldwide.

To date the Gapman Gen3 has achieved a gap measurement/shimming operation schedule five times faster than the feeler gauges. Additional benefits are reduced overall cost, enhanced structural integrity of aircraft components, and a gap measurement database to assist in process improvement. As an added benefit it reduces lead times while measuring more gaps without the risk of manual data transfer.

Continuous customer feedback has driven development of additional features that further increase ROI and reduce gap measurement and shimming times. The new Gapman Set to Standard calibration software processes enable the Gapman Gen3 to be more easily recalibrated for a wide variety of target material combinations such as CFRP (rough and smooth surfaces) and metal (painted or non-painted surfaces).

ABOVE: Gapman test results with offset calibration

THE BACKGROUND

The Gapman system functions using non-contact capacitive gap measurement. The physics behind this sensing technology is that there are three factors that can influence the reading. The first is the gap that the users are trying to measure. Second is the sensor spot size, which is typically constant. The third is the dielectric constant between the sensor and the conductive target surface. This is a combination of the air gap (characteristically constant) and the dielectric surface material on the conductive target, which can vary due to the plastic resins, glass laminate surfaces or paint between the conductive target and the sensor face. These coatings cause slight variability due to the thickness and dielectric constant values. It is worth concentrating on the dielectric coating materials that cause this variation and affect the accuracy of the measurement. The focus is on the use of CFRP painted, smooth or rough surface resins as compared with painted or clear metal. Fortunately these coatings are uniform through the manufactured structures being measured.

To minimize or eliminate gap measurement errors, aircraft users must have a rigorous policy of matching calibrations to the various target combinations. These dedicated calibrations take into account the particular influences of each pair of gap targets. This matched combination provides a traceable solution for metrology calibration labs because they know that the data is certified to lab standards. The downside to this approach is the added time to support these multiple Gapman calibrations.

An additional concern is the ability of calibration labs to build well-controlled flat painted or CFRP targets. They are very costly to produce and it is difficult to control the flatness to the typical 25-50µm tolerances using readily available matched CFRP material as standards for calibration. These targets are typically cut from available stock and can have excessive radii. The preferred metrology sample flatness goal is 1µm for calibration target standards.

METAL-TO-METAL

A solution to this problem is available from Capacitec, combining the Gapman Set to Standard software with a simple baseline metal-to-metal calibration (Figure xxx1). When used in conjunction with certified metal calibration blocks as targets, well-controlled, highly repeatable certified gap measurement can be achieved. Capacitec performed a study comparing the metal-to-metal calibrations with a variety of different target materials, focusing on CFRP combinations. The results showed that 80% of the deviations from the readings are simple offset value adjustments.

The table in Figure xxx2 shows how the company has successfully takes advantage of the Set to Standard process using a series of custom offset adjustments correlating to the target material and finish. This figure specifically shows the differences between the baseline metal-to-metal calibration and the subsequent nominal gap readings between metal-to-CFRP smooth combined targets.

A unique best-fit offset, derived from the standard deviation for each material type, can be applied if the user requires tight linearity (25µm or better). If the linearity is not as stringent (50µm or better), one single average of all best-fit offset adjustments across all material combinations may work. The data shows that by applying this best-fit offset (31µm/0.031mm average deviation) to any of the data will result in greatly improved linearity of 8µm (0.008mm), as shown in the right-hand side of the table. CFRP-to-CFRP rough glass targets, tested but not shown here, represented the largest deviations (about 100µm) in output due to the unique surface dielectric coatings of the materials used (and not being conductive metal).

The compromise of making just an offset adjustment leaves a slightly higher residual non-linearity due to the slope variation of the material combination. Engineers can investigate whether this offset-adjusted variation meets the requirements of their particular assembly. This new approach to certified gap measurements creates added efficiency of the complete shimming process.

Furthermore, a new Gapman Gen3 wireless option has a higher level command set of communication protocols to enable an external software program to adjust the Set to Standard offset of any material combination (CFRP-to-metal etc) being measured at any location. Customer-designed database software could apply this offset value by communicating via the wireless option. Calibration check standards can also be used in production to validate proper operation without the additional cost burden of special composite standards for each gap target combination.

The Gapman Set to Standard calibration process can have a major impact on improving gap measurement and shimming process throughput. It also improves the quality of calibration recertification as it is based on known metal/metal standards while reducing the time it takes to certify under normal metrology cycles. ∎

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