Application Note for
the Aviation Industry

Rivet Hole and Rivet Flushness Inspection

with Novacam RivetInspect System

Keywords: 3D industrial inspection, internal ID defects, ID dimensions, ID surface roughness, countersinks, rivets, pins, bolts, blind fasteners, delamination, non-contact, non-destructive inspection, NDT, robot tools, end-of-arm tooling

Introduction

Automating fastener inspection in aircraft assembly is no longer just an option – it is now a necessity for aircraft makers who are facing stiff competition and increasingly higher precision QA/QC requirements for each aspect of the assembly process. Since the traditional drill-and-fill process accounts for over half of airframe assembly costs, manufacturers are looking to improve the fastening process through a combination of fully automated robots for the majority of riveting, and flexible semi-automated tools for hard-to-reach spaces.

The RivetInspect system provides high-speed high-precision defect detection capabilities for the entire riveting process in aircraft assembly. Based on low-coherence interferometry, the system acquires dimensions of all surfaces requiring inspection: the rivet hole inside walls, the countersink walls, as well as rivet flushness.

Figure 1: The small-diameter probe of the rotational scanner reaches inside rivet holes to acquire the complete inside surface geometry

The dual optical scanners of the system acquire up to 100,000 points/second and are easily integrated as either robot end-effectors or as vision components in automated or semi-automated systems on the plant floor. A small-diameter probe of a rotational scanner easily reaches inside rivet holes (see Figure 1) to acquire their dimensionality and detect defects (see Figure 2). A galvo scanner (raster scanner), attached to the same profilometer, acquires the 3D countersink surface and the rivet-head area to assess flushness (see images on page 3).

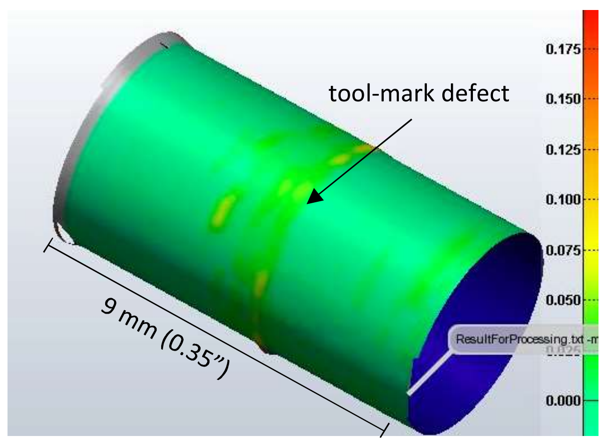

Figure 2: The inside (ID) surface of this rivet hole exhibits a tool-mark defect at the interface of composite and aluminum layers

Inside the Rivet Hole

The micron-precision 3D surface data acquired by RivetInspect provides manufacturers with unprecedented level of defect detection as well as insight into the drilling process.

Replacing contact and roughness measurements, 3D characterization will, for example, reveal evidence of **inter-laminar or exit burring**, such as shown in Figure 3.

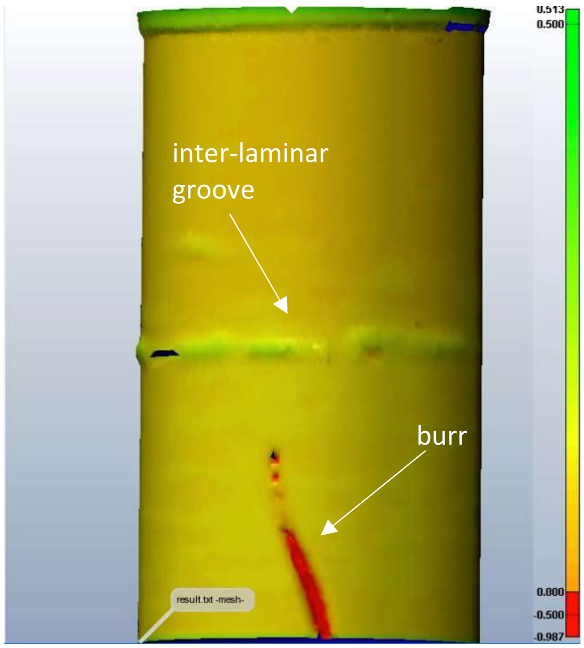

Figure 3: Inside surface of a rivet hole exhibiting a burr - an easy defect to instantly detect and identify with RivetInspect

Addressing burrs inside rivet holes is costly. Depending on the severity of burring, corrective measures may include disassembly and removal of burrs or chips prior to re-joining the surfaces. Deburring tools do help circumvent disassembly but deburring is best avoided, particularly when it comes to composite components, where deburring may introduce debris between the composite skin and the metal substructure.

High-precision automated rivet-hole inspection that directly follows the rivet hole drilling prevents burr defect propagation and unnecessary corrective rework. What is more, rapid burr defect diagnosis leads to rapid rectification and resumption of the drilling process. Since the severity of burrs formed is impacted by the physical and operational parameters of the drill and bit, burr detection is typically a signal for immediate replacement of a drill bit.

Delamination of composite material layers or excessive fiber pulling or tearing caused by drilling are similarly revealed with the high-precision 3D data acquired by RivetInspect. Again, timely detection of such a defect enables prompt investigation of the joined components or of the drill tools and process.

Replace the Drill Bit on Time – but not Too Soon

Given the cost of consumable drill bits and the cost of the drill-bit replacement process, it makes sense to replace drill bits only once their efficacy has measurably deteriorated. To establish drill bit wear, the acquired 3D rivet-hole inner surface geometry is programmatically compared with the design specification shape of the rivet hole (see Figure 5). The scale of dimensional variation suggests the optimal time to replace a drill bit, before defects start occurring. With this drill-bit replacement approach, operational savings are achieved.

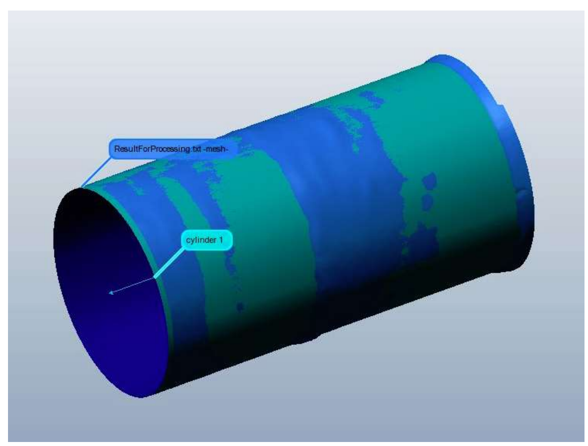

Figure 5: Colour-coded image of dimensional variability between the rivet-hole specification (green) and the rivet hole (blue)

Inside Countersinks

Since flush head fasteners are crucial for exterior aerodynamic surfaces, the nominal depth of a countersink must accommodate the rivet head to achieve flushness. With the optical data acquired at high speed by RivetInspect galvo scanner, countersink surface is imaged in 3D (Figure 6). Conformity to specifications (such as the angle of the countersink) is easily verified (Figure 7) and any surface defects identified (Figure 8).

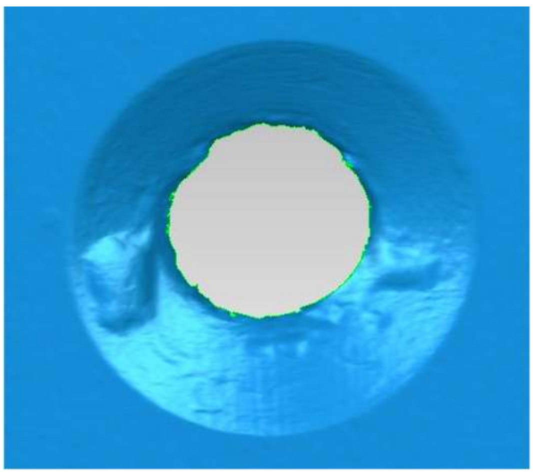

Figure 6: 3D surface of a countersink

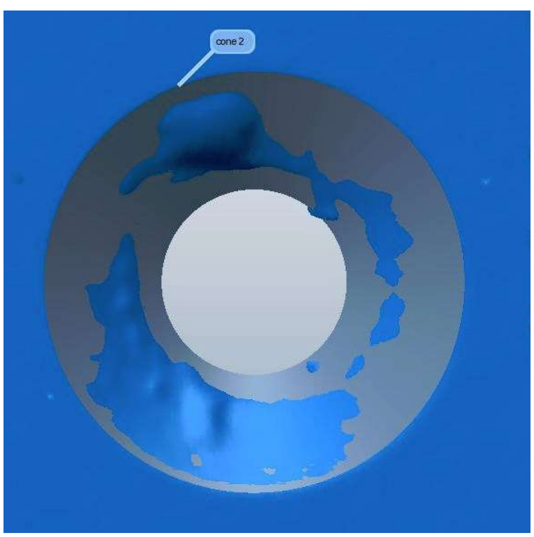

Figure 7: Variability of the 3D actual countersink (blue) from the spec (gray)

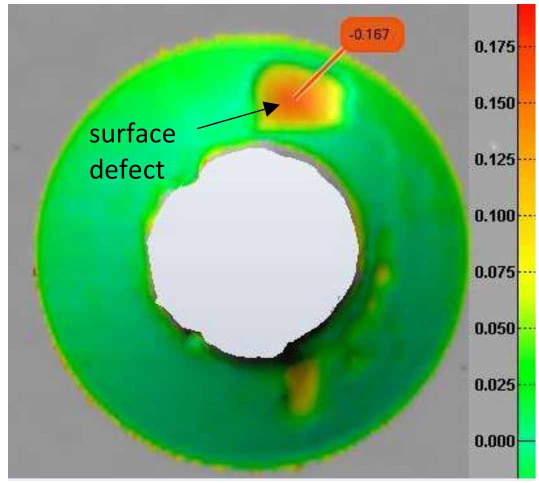

Figure 8: Surface defect identified on the countersink

Checking Rivet Flushness

Since flushness of the rivet, as determined by aerodynamics, must be within the range of 0.002 inch (50.8 microns), micron-precision surface dimensional data (Figure 9) easily verify conformity to specifications.

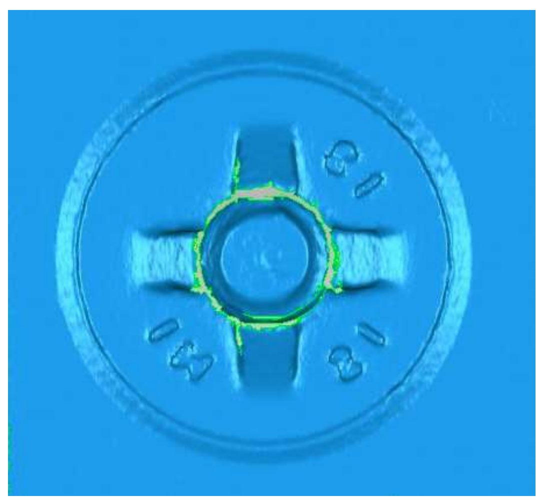

Figure 9: 3D surface of an installed rivet head

Even surface defects around the rivet head, such as skin distortion, rivet removal damage, scratches, or other types of deformation, can be detected. The field of view of the RivetInspect galvo scanner can cover 30 mm^2.

Helping Automate the Riveting Process

As inspection end-effectors on state-of-the-art aviation industry robots, RivetInspect scanners assist in a range of aircraft assembly tasks including drilling, fastener installation, sealing, and machining operations (such as deburring).

The non-contact optical scanners enable 3D metrology anywhere, even in harsh (radioactive, very hot or cryogenic) environments. Being fiber-based, they can be deployed hundreds of meters away from the profilometer enclosure without signal degradation.

Hard to Reach Corners

For inspection needs of riveting or bolting applications in hard-to-reach spaces, RivetInspect scanners are integrated into custom hand-held inspection tools appropriate to the particular environment.

Conclusion

RivetInspect brings important inspection capabilities to the aircraft riveting process: versatility of installation, high-speed acquisition, and sub-micron-precision dimensional measurements. Typical RivetInspect system components are listed below.

RivetInspect system components

<table>
<tr><th>Component</th><th>Physical aspect</th><th colspan="2">Deployment area</th></tr>
<tr><td>MicroCam-3D or 4D interferometer</td><td>19” rack-mountable instrument</td><td colspan="2">plant floor / control room</td></tr>
<tr><td>workstation computer</td><td>mini desktop-size PC or laptop</td><td colspan="2">plant floor / control room</td></tr>
<tr><td>rotational scanner</td><td>Rotational scanner featuring a small-diameter* side-looking probe</td><td>rivet hole inspection</td><td rowspan="2">on the plant floor as:
- robot end-effectors
- 3D inspection instruments in automated assembly lines
- 3D-vision components in hand-held inspection tools</td></tr>
<tr><td>galvo scanner</td><td>surface scanning galvanometer probe</td><td>countersink and rivet flushness inspection</td></tr>
</table>

* Novacam rotational probes come in diameters as small as 0.5 mm (0.02”)

Detailed technical specifications are available upon request.

Novacam encourages technicians and engineers in charge of aerospace assembly applications, including fastener installation, to contact us to discuss your applications and particular challenges.

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