X-RAY INSPECTION IN THE AEROSPACE INDUSTRY - STATE OF THE ART, CHALLENGES, AND EMERGING TECHNOLOGIES

G. A. Mohr[1] and T. Fock[2]
[1] GE Inspection Technologies, Cincinnati, OH; [2] GE Inspection Technologies, Ahrensburg, Germany

Abstract: The desire to non-destructively determine the quality and integrity of materials and structures has a long history in the aerospace industry. Through the entire life cycle of aircraft products and components, X-ray inspection technologies play a major role with continuously increasing demand. The requirements for X-ray inspections are continuing to be driven by the need of lower cost methods and solutions with greater reliability, sensitivity, user friendliness and high operation speed as well as applicability of new materials and structures. The presentation will summarize the status of radiographic and radioscopic X-ray inspection technologies in the aerospace industry while showing how X-ray inspection solutions respond to these requirements. Furthermore emerging inspection challenges will be identified and emerging X-ray inspection technologies will be reviewed.

Introduction: Modern aircraft, both commercial and military, are designed for effective operation over long life cycles. Safety and performance requirements mandate that extensive inspections of flight-critical components and assemblies be performed throughout the aircraft life cycle. Typical criteria for critical flaw sizes are often determined from empirically validated models of defect growth and effects during cyclic fatigue. This applies both to inspections performed during manufacture and to periodic inspections performed in the field or at service facilities throughout the aircraft life. The ability to reliably detect flaws at smaller sizes can reduce the necessary frequency of inspection.

The most prevalent form of aircraft inspection is visual – whether in the form of a pre-flight "walkaround" or as the detailed visual inspections of structural requirements performed during heavy maintenance "D" checks on commercial airliners. However, advanced non-destructive methods are often employed to inspect for flaws hidden from view or too small to be reliably found with more simple methods. X-ray methods are particularly suited for assessment of internal integrity in a variety of aerospace applications.

Results: The typical x-ray inspection process involves several steps. First, x-ray images (either radiographic or radioscopic) of the component under test are acquired. Second, those images are converted to a useful format and presented to a skilled individual for interpretation. Finally, the data and results must be documented, archived, and communicated.

Of course, inadequate performance at any of these three steps, from either a cost or performance standpoint, can lead to degradation of the overall inspection process. But improving key process steps also can lead to more effective inspections, as demonstrated below.

Example 1: Improved radioscopic image quality. Image intensifiers were previously used to examine the internal structure of closed, welded components used in military jet engines during regularly scheduled service. The real-time nature of the inspection allowed inspectors to rapidly determine whether the components were serviceable, or whether they required disassembly and weld repair before reuse. False positive calls occurred with regularity, and the repair personnel often wasted effort locating indicated repair locations.

The conventional imaging chain was replaced by a high-performance 30-Hz flat panel detector system. The quality of the real-time images used to search for defects was significantly improved. Substantial benefits were realized because the inspections became faster – much less time was spent by the inspectors in characterizing and dispositioning potential defects that had marginal detectability. Further, because the review station provided annotation capabilities, many fewer instances were noted where welders repaired the "wrong" areas.

Example 2: Reduced film/developing cost. Film, chemical, chemical disposal, and darkroom costs were significantly reduced when conventional film x-ray for detection of small cracks in inside layers around airframe door and windows was replaced by computed radiography, despite a relatively low volume of like inspections.

Example 3: Improved inspection throughput. A manufacturer of brazed jet engine components replaced conventional film x-ray with a flat panel detector. The digital solution was adequate for the great majority of parts, and exposure times were ~10 seconds, and developing time was completely eliminated.

Example 4: Improved manufacturing operations. An automated x-ray system with source, robot, and flat panel detector was installed to inspect turbine blade tip weld repairs. Inspection throughput more than doubled, with no increase in operators or over-time. This allowed the plant to re-engineer flow, and institute an incoming inspection for all parts returned from service. The final result was a reduction of 5 days in TAT time – and significant financial impact.

Discussion: The above examples are not meant to imply that every x-ray inspection application can benefit from new technology. Every radiographer is familiar with the trade-off between film image quality and speed. Similar trade-offs between investment and financial return must be balanced when considering the use of new inspection technology to replace old. But in many applications, a solid case can be made for the benefits when all three phases (acquisition, review, communication) are considered in the context of inspection operations.

Conclusions: X-ray inspection methods, whether conventional or advanced, continue to have a significant role in manufacturing and maintaining flight-worthy vehicles in the aerospace industry. X-ray inspection operations often can be improved, in terms of both overall cost and flaw detection reliability, when specific applications are evaluated for improvement through the application of process analysis and new technologies.