Computed Radiography Systems for Radiographic Testing of Commercial Aircrafts

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Abstract

Radiography non-destructive testing method is one of the most important tools for aircraft maintenance procedures which can be effectively detect different kind of defects in aircraft structures. In this study, Computed Radiography (CR) testing method is used for defects detection in commercial aircrafts such as Falcon-20 and Fokker-100. Both conventional film RT and Digital RT are implemented and compared. Computed radiography (CR) is potentially applicable in the same cases as film. It offers faster results without chemical processing. Instead of conventional film, a phosphor plate is substituted for the sheet of film images. Radiography tests were done on some parts from both aircraft. CR images show a very vast dynamic range and good spatial resolution. However in very high resolution application, digital methods cannot compete with conventional film radiography. In this research, spatial resolution of CR images was determined by Duplex IQI. It was shown that basic spatial resolution was around 70 Micron in our case, which is comparable with AGFA D7 film. SNR values were around 60 which are reasonable. Considering contrast, for conventional RT film, it is difficult to obtain the same quality radiographs in comparison with digital radiography system. Considering the dynamic range, digital RT systems show a very wide dynamic range in comparison with conventional film. Finally, it was shown that Computed Radiography (CR) system has a complete superiority over the conventional film radiography system in dynamic range, contrast, signal to noise ration and crack detectability for the aerospace application.

Keywords: Computed Radiography; Film Radiography, Commercial Aircraft; Image Contrast, Spatial Resolution.

1. Introduction

Cracks are still a major problem in new aircrafts. "Hairline cracks" had been discovered in the wings of about 40 new B-787 Dreamliners that are in production. Boeing said the 787 cracks occurred in shear ties on wing ribs. Airbus also has encountered with wing cracks on its A380 fleet [1]. Radiography non-destructive testing method is one of the most important tools for aircraft maintenance procedures which can be effectively detect different kind of defects in aircraft structures, including cracks. X-ray radiography is usually used for the detection of defects like cracks and corrosion on aircraft windows, wings and fuselage [2]. Conventional film radiography and computed radiography are two common methods which can be used for aircraft inspection.
Film radiography is the oldest method of radiography which is still considered an excellent technology. High spatial resolution is the most important benefit of film radiography. Because of that, film radiography has important role in inspection of castings or forged metal parts—e.g., airfoils, pumps, pump housings, gears, struts or landing gear components—where its sensitivity and high image resolution are particularly appropriate for identifying fine cracks or flaws that could lead to failure. Film radiography has some disadvantages, for example film inspection requires photographic development which is a potentially problematic, time-consuming process involving chemicals harmful to inspectors and the environment.

Computed radiography (CR) is potentially applicable in the same cases as film. It offers faster results without chemical processing. Instead of conventional film, a phosphor plate is substituted for the sheet of film. Images are read by a special laser scanner and image stored digitally for later review and archiving. Aerospace manufacturers must keep permanent records, thus this archiving method is valuable in aerospace applications. Some phosphor-plate readers can be situated conveniently in a van or truck. For mobile inspection operations this can be valuable and it reduces transportation capacity which is essential for on-site image examination. Because of more sensitivity and greater dynamic range of phosphor plates than film, CR also can reduce the exposure time needed to generate an image and this is a benefit which increases life of the X-ray source. Nowadays, because Current plate technology has some resolution limitations, film remains the preferred medium for critical, very high-resolution imaging. It is noticeable that the new high resolution phosphor imaging plate introduced in recent years. This high resolution imaging plates can be used in the most high resolution application and can reach up to 25 micron spatial resolution.

2. Methods

In this study, industrial radiographic testing method (RT) is used for defects detection in commercial aircraft structures such as Falcon-20 and Fokker-100 aircrafts. Both conventional RT and Digital CR are implemented and compared.

2.1 Equipment

The radiography experiments were done by a 300 kVolt x-ray machine (Pantak-Seifert, Eresco 65). This X-ray system was used for all radiographic exposures, both film and Imaging plate. Industrial radiographic film, KODAK MX-125 was used for necessary radiographic tests. A manual method was used for processing of the exposed films. Also Computed radiography (CR) system with ordinary phosphor imaging plates was implemented as the digital radiography system. The imaging plates were scanned in the CR laser scanner with laser spot size of 50 μm. A high resolution monitor (3 mega pixels) was used to display the radiographic images captured through the CR system.

In each radiography experiment, image quality of radiograph must be determined. It is important to notice that image quality indicators (IQI), hole type and wire type, are not enough in digital radiography. Using the duplex type IQI is obligatory for digital radiography. Fig. 1 shows different types. The basic spatial resolution of system is defined as

\[ SR_b = U_g / 2 \]  \hspace{1cm} (1)

Where \( SR_b \) is spatial resolution and \( U_g \) is geometrical unsharpness.

Also signal to noise ratio (SNR) and Contrast to Noise Ratio (CNR) are related as:
In which \( \mu_{\text{eff}} \) is the linear attenuation coefficient and can obtained from relation no.3.

\[
I = BI_0e^{-\mu_x}
\]  

(3)

2.2 Test Procedure

Fig. 2 shows images of our first test specimen, i.e. a CR image of Falcon-20 landing gear. The photo and radiograph of the test specimen are shown. CR image of landing gear part has a very good contrast in comparison with conventional film radiography.

The second test specimen is a part of an engine cover (intake lip) of F-100 aircraft which is shown in Fig. 3.
Figure 4a shows a digital radiograph of the engine cover (intake lip). In part b, digitized film radiography of the same object can be seen. The corrosion could be seen clearly in this part. With conventional RT, it is difficult to obtain the same quality radiographs with normal RT procedures.

The spatial resolution of CR system was calculated to be around 80 micron using Duplex IQI and relation No.1. This value is good enough in the most applications.

3. Results and Discussion

CR images show a very vast dynamic range and good spatial resolution. However in very high resolution application, digital methods cannot compete with conventional film radiography. In this research, spatial resolution of CR images was determined by Duplex IQI. It was shown that basic spatial resolution was around 70 Micron in our case, which is comparable with KODAK AA-400 or AGFA D7 film. SNR values were around 60 which are reasonable. Considering contrast, for conventional RT film, it is difficult to obtain the same quality radiographs in comparison with digital radiography system. Considering the dynamic range, digital RT systems show a very wide dynamic range in comparison with conventional film.

Finally, it was shown that Computed Radiography (CR) system has a complete superiority over the conventional film radiography system in dynamic range, contrast, signal to noise ration and crack detectability for the aerospace application.

References