1.4.8. TWO NEW COMPENSATION PRINCIPLES IN DIGITAL INDUSTRIAL RADIOLOGY FOR ENHANCEMENT OF IMAGE QUALITY, EFFICIENCY AND INDUSTRIAL ACCEPTANCE

Ewert U., Zscherpel U., Jechow M., Beckmann J., BAM, Berlin, Germany;
Bavendiek K., YXLON International GmbH, Hamburg, Germany

Digital Radiology (DR) as Computed Radiography (CR) and radiography with Digital Detector Arrays (DDA) has been successfully introduced in medicine since more than 15 years. The application of medical DR products for NDT was mainly restricted due to its high image unsharpness. Most medical DR detectors need low radiation dose for its exposures and are, therefore, attractive for NDT applications from the economical point of view. NDT of welds and castings as well as electronics requires high definition systems or magnification technique since small cracks and flaws have to be visualised in contrast to most medical diagnostic requirements. Specialised medical developments of detectors for mammography and tooth inspection with 50 µm pixel size are in many cases sufficient for NDT, but the detectors are optimised for low radiation energy application and therefore inefficient for the typical NDT applications between 100 and 400 kV.

Two compensation principles are proposed for practical application and optimization of the described technology for digital industrial radiography:

Compensation principle I: The increase of the Signal-to-Noise Ratio (SNR) of images depends on the exposure conditions. The SNR increases with the square root of mA·minutes, but it is limited to a maximum value due to the detector's structure noise. This arises from calibration inaccuracies of DDAs or the crystalline structure in the photo sensitive layer of the imaging plates. In film radiography it is well understood that the image quality increases, if the tube voltage is reduced. In DR it can also be observed that the image quality increases if the tube voltage is increased. The higher photon flow (X-ray intensity behind object) increases the SNR in the detected image faster than the reduction of the contrast by the decreased transmission contrast (also known as specific contrast or effective attenuation coefficient μ_{eff}). This effect is based on the physical dependence of the Contrast-to-Noise Ratio (CNR) per wall thickness difference (Δw): $CNR/\Delta w = SNR \times \times \mu_{eff}$. Therefore, it has been proposed to revise standards as EN 14874-2 and EN 1435-2, which obtain the limitation for the maximum tube voltage. This limit should not be maintained anymore for DR because decreasing contrast is compensated by increased SNR.

Compensation principle II: The European standard EN 14784-2 requires in tab. 4 the application of high definition CR systems for X-ray inspection with pixel sizes of less than 50 µm for class B inspection (for wall thickness < 12 mm and tube voltages < 150 kV). Most available systems do not allow a resolution below 50 µm pixel size and are excluded from industrial X-ray inspection in Europe. Recent trials have shown that DDAs provide a better image quality and IQI visibility than industrial X-ray films [1]. Especially DDAs allow in the high contrast sensitivity mode a better IQI reading than film exposures. This effect is observed when subpixel contrast resolution is achieved. This is the case, if the SNR at the detector is increased considerably. If a wire or crack is smaller than a pixel, it still influences the contrast and can be seen in the image if the contrast is sufficiently higher than the noise. Therefore systems with insufficient spatial resolution can be applied if their too high unsharpness is compensated by increased SNR. It is proposed now, to permit the application of unsharp systems, if the required visibility of the wire or step hole IQI is increased correspondingly for compensation of missing duplex wire resolution (see EN 462-5, ASTM E 2002 and requirements of EN 14784-2). Typically one higher (smaller diameter, see EN 462-1) single wire shall be seen if one duplex wire is missing in the system qualification.

The compensations principles will be explained and examples of the NDT practice are presented.

[1] Bavendiek K., Heike U., YXLON International, Hamburg, Germany; Meade W.D., BOEING Commercial Airplane Group, Seattle, USA; Zscherpel U., Ewert U., BAM, Berlin, Germany, New Digital Radiography Procedure Exceeds Film Sensitivity Considerably in Aerospace Applications, 9th ECNDT, Berlin, 25–29.9.2006, Proceedings CD, Th.3.2.1.pdf.