1.4.12. AUTOMATING THE X-RAY INSPECTION

Herold F., Kramm P., Adamczak U.,
YXLON INTERNATIONAL, Hamburg, Germany

Each part to be inspected (e.g. castings, tubes, composites etc.) leads to its own specific requirements concerning quality assurance. The requirements mainly depend on the fields of application and whether the test parts are used under safety-critical conditions.

Third generation X-Ray inspection systems [4] are well known as robust and reliable fully automated defect recognitions systems (ADR systems) for many different test parts. Such systems have become the standard for X-Ray based non-destructive testing (NDT). For aluminum castings they are mandatory particularly in the automotive industry for safety-critical parts like wheels, 'knuckles', pistons etc.

But even in the aviation technology X-Ray inspection replaces and outpaces the classical film based inspection by using high-quality digital flat panel detectors [2]. Digital image-processing software-algorithms similar to the algorithms of ADR systems will also arise as the methods of choice in such applications.

Nevertheless a huge variety of parts to be inspected exits that is not suitable to be inspected in a batch process. Prototypes, small series or even a series of unique parts for example are still inspected visually and not by ADR.

Visual systems have still an amount of over 50% in the automotive market for example. Furthermore, in the other markets like aerospace etc. nearly all used X-Ray inspection systems are visual systems.

But also these systems benefit from the latest technologies of the digital image-processing hardware and software.

Modern fully automated as well as visual digital X-Ray inspection systems are well-equipped by an high-power X-Ray tube (e.g. with variable focal spot size) and an high-performance digital flat panel detector that provides spatial resolutions up to 200 µm and 30 Hz per full-frame. Today, the dedicated manipulator systems perform fast and precise movement of the test parts. These manipulators are also controlled digitally by software.

Therefore the human user is able to adjust and control the X-Ray, the imaging as well as the mechanical manipulator system through only one user-friendly graphical interface by software.

Most of the adjustments that an human user has to apply in state-of-art X-Ray inspection systems, mainly in visual, but also in ADR systems, are not only time consuming, they are due to the digital control of the system not necessary.

Automating the X-Ray inspection will save costs and will help the human inspector to concentrate on NDT and not on adjusting his inspection system.

This article will give an overview on the potential of automating X-Ray inspection using intelligent software algorithms that handle the adjustment of the X-Ray tube, the digital flat panel detector and the mechanical manipulator automatically. The performance of the latest developments will be presented.

Especially the following items are evaluated:

– System qualification is used to ensure a reliable imaging system providing constant image quality for a long term automatically by using methods in compliance to EN 462-5 (platinum duplex wire) or ASTM E 1025 / E 1742 (penetrameters with 1T and 2T holes);

– Automatic gray-scaling [3] to visualize the most important image information to the human inspector. For example digital flat panel detectors provide 65536 shades of gray, whereas the human can only differentiate about 60 shades of gray;

– High dynamic radioscopy (HDR) [1] to enhance the structural details of test part;

– Fully automated detector calibration to get for each application the best image quality (see [2]). In modern X-Ray inspection systems the power of the X-Ray source and the manipulator positioning the calibration object are controlled automatically without any user-interaction during the calibration process. Depending on the currently set system parameters, the software will choose the best fitting calibration data-set to ensure always an excellent image quality;

– Automatic X-Ray control to adjust the optimal dose of the X-Ray source depending on the appropriable signal range of the dedicated imaging detector. An overdose control is already known from image intensifier systems. But by using intelligent software algorithms more complex control loops are applicable;

– ADR-Systems are fully automated concerning the batch testing [4], but still some few adjustments are needed, e.g. defining regions inside an image of the part. Intelligent image-processing algorithms [3, 5] are able to distinguish between material and background generally and are able to pre-define a suitable region automatically.

This article has shown how to benefit from the manifold possibilities of controlling the X-Ray, the imaging and the mechanical manipulator system digitally and automatically by software. Intelligent image-processing algorithms are able to ease the needed adjustments of an X-Ray inspection system. The performance analysis shows, what is possible today and gives an outlook to what is expected for the next time.

References:

1. **Bavendiek K., Heike U.** “HDR Hoch Dynamik Radioskopie”, DGZfP Jahrestagung 2009, Münster, Germany.
2. **Bavendiek K.** “Film, CR, and Flat Panel Detectors for BAM 5 Reference Weld”, ASTM Conference, Reno (NV), June 2005.
3. **Gonzalez R., Woods R.** “Digital Image Processing”, 2nd edition, Prentice Hall, Pearson Education, Upper Saddle River, New Jersey, 2002, ISBN: 0-201-18075-8.
4. **Herold F., Frantz S., Bavendiek K., Grigat R.** “Building Blocks of Third-Generation Automatic Defect Recognition System”, 9th European Conference on NDT, September 2006, Berlin, Germany.
5. **Soille P.** “Morphological Image Analysis”, 2nd edition, Springer, Berlin, Germany, 2003, ISBN: 3-540-42988-3.