1.9.14. AN OWN-DEVELOPED CT/DR SYSTEM FOR VISUALIZATION AND DEFECT RECOGNITION IN NDT

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Summary. We have developed an industrial X-Ray computed tomograph that also provide digital radiography images (CT/DR) for dimensional and general non-destructive testing inspection in AIMEN, Spain, in collaboration with the University of Santiago de Compostela (Spain).

The system, fully operational at 2009, consists on a 1 m long detector array of 1280 detecting elements with submillimetrical spacing, together with a 225 kV mini-focus tube, integrated in a 3-axis positioning system of flexible configuration. Their most remarkable features are the image variable magnification and the capability of capturing both tomographic and radiographic images.

A second project involving this CT/DR is currently underway. In this project software is being developed for visualization and automated defect recognition of the acquired images. The software accomplishes visualization and automated analysis for radiographs, sinograms and CT reconstructed images including the possibility of generating 3D images from the CT slices.

Introduction. Nowadays the X-ray technology and computed tomography are often applied in non-destructive testing in industrial production. These techniques can be used in many areas, usually oriented to specific production in a specific area. The technological centre AIMEN is oriented to welding technology but also has different research departments. The AIMEN Inspection department has therefore to cover different kind of pieces: from welded ones to composite aeronautical pieces and even biological probes. This implies a large amount of different type of images in terms of size and density, leading to the development of a customized CT/DR system in AIMEN.

The first part of the project implied the development of the hardware and basic software for acquisition, simple reconstruction and visualization. The second part consists on the development of software for displaying and analyzing the images generated by the CT/DR system.

Fig. 1. Example of a sinogram visualization

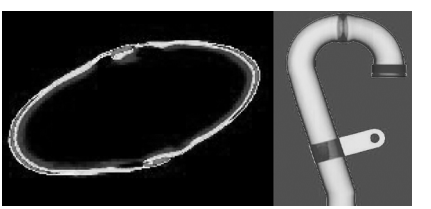

Fig. 2. Example of different kind of images: reconstructed tomographic slice (left) **and digital radiograph** (right) **of a brazing tube**

Results.

CT/DR system. The industrial CT/DR system developed in AIMEN is comprised of an X-ray tube up to 225 kV and 0.2 mm focus size. It is a tungsten target monopolar tube, cooled with water. The detector is a linear array of cadmium tungstate with 1280 active elements of 0.8 mm pitch. The signal is read and processed by 10 individual electronic boards, with a control board that indexes data to the computer by a digital I/O PCI frame-grabber.

Positioning of the system has been implemented as a tri-axial system allowing for a flexible configuration and scan sequence. It integrates two motorized linear stages where the detector and the tube are located for synchronized movement, along with a rotary stage for positioning the piece to inspect. This stage is situated over a linear horizontal stage, making possible to vary the source-object distance. In this way the system is able for acquiring both tomographic slices and digital radiographs, and also for modifying the image magnification factor.

Acquisition and Display. Control software has been developed in LabVIEW code integrating both mechanical positioning and data acquisition. Read data is stored in binary format, for late reconstruction.

Analysis of digital images (radiographs, sinograms) was implemented with the Matlab (www.themathworks.com) Image Processing Toolbox, along with the reconstruction algorithm for tomographic images. The algorithm is based on the filtered back-projection method, and the resulting images were stored in the Analyze SPM format (http://mayoresearch.mayo. edu/mayo/research/robb_lab/ analyze.cfm).

Display of images is performed by means of the own-developed software that enables to show the different formats of the stored images to the user/customer. The software has been developed in C++ by using multiplatform graphic libraries, thus it can run on the most popular operating systems (Windows, Linux, MacOS). The software was designed as a user-friendly tool, allowing the user to select images from the filesystem, to modify its size by means of zooms, to change the bright and contrast and to depict different curves related to profiles and histogram of the selected image. The software includes a tool for 3D visualization of CT volumes, based on OpenGL libraries. Finally the software includes tools for defect analysis, currently under development, where the adaptability to the different images is crucial.