1.4.10. RADIOGRAPHIC TESTING SIMULATION WITH CIVA-RX – ASSESSMENT ON REPRESENTATIVE NUCLEAR COMPONENTS

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NDE methods are commonly used for the inspection of nuclear installations for maintenance operations. The simulation can be very useful to evaluate the performances of NDE methods, in addition to experimental evaluation on mock-ups. A new Gamma and X-Ray simulation module has been recently integrated in the CIVA software platform in addition to already available UT and ECT modules. The X-ray module [1] is based on a combination of NDT radiographic modules developed at the CEA LETI and at EDF R&D.

The French Institute for Safety and Radioprotection (IRSN) is using the NDE simulation to complete expertises and to give recommendations on NDE applications. Some years ago, a research program funded by IRSN was initiated to study the benefits of X-Ray simulation tools for the assessment of NDE methods on nuclear applications. Some specific cases were studied in order to point out the capabilities of simulation software to provide useful information on the ability of X-ray methods to detect defects in realistic configurations such as complex geometries or materials.

X-ray simulation for nuclear inspection has several specificities:

– The sources are Gamma-Rays (Iridium 192 or Cobalt 60).

– The objects under evaluation are made of thick steel of similar alloys e.g. inconel (20 to 130 mm). This leads to dominant scattering contribution.

– The defects are small and very anisotropic (mainly cracks 20 to 200 μm). The aperture is a very important feature.

– The detectors are made of an assembly of sandwiches of radiographic films and metal screens protected by filters.

Due to the dimension of objects and defects, it is necessary to combine the direct radiation image computed from an analytical approach (raytracing and Beer-Lambert law) and the scattered image (Monte Carlo simulation) simulated with a moderate number of photons and then filtered either through polynomial fit or a low – frequency filter.

The film response, which is strongly non-linear, is described either from the EN584-1 standard, or from a mix of manufacturer data sheet and experimental data. The grain noise or the quantum noise can be simulated and the detector blur can also be simulated but must be experimentally validated and is generally neglected compared to the source blurring. The source blurring can also be taken into account.

In the framework of the study, simulations have been performed on typical applications encountered in nuclear inspection of primary or secondary circuits of pressurized water reactors: nozzles, dissimilar metal welds and irregular profile piping. The complex components are described using CAD geometries. For dissimilar metal welds, heterogeneous materials are taken into account. For defects, different descriptions are used: planar, curved trapezoid, CAO3D defects or cracks.

One example of planar defects detection in a primary circuit nozzle is shown on fig. 1.

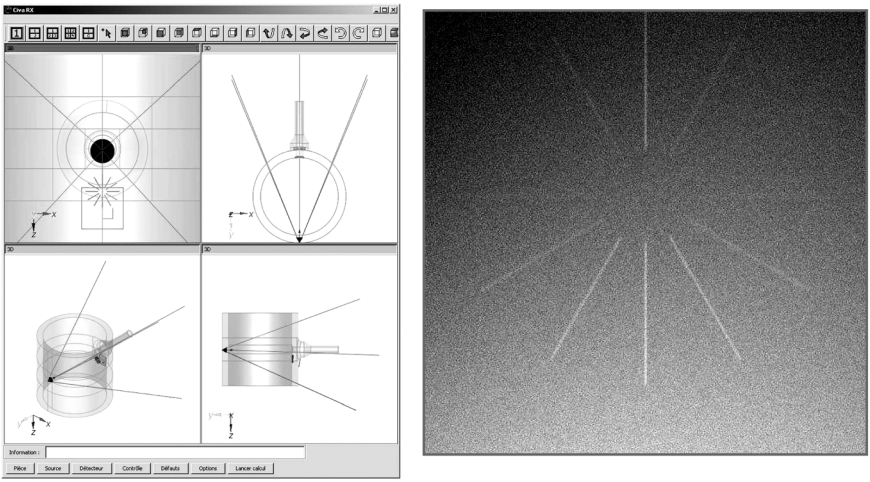

Fig. 1 Nozzle. Double wall examination with Cobalt 60. C2 class film. Planar defects with different orientations

The simulations presented in this paper show how CIVA can simulate complex configurations and produce realistic images on some typical applications.

References:

1. **Fernandez R., Schumm A., Tabary J., Hugonnard P.** Simulation studies of radiographic inspections with CIVA / 17th WCNDT, Shanghai, 2008.