

CIVA WORKSTATION FOR NDE : MIXING OF NDE TECHNIQUES AND MODELING

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INTRODUCTION

Non Destructive Examination (NDE) plays an important role in numerous industrial fields. They are used both in production tests (improvement of product quality, process monitoring) and in facility inspections (installation safety, component life times). Various types of inspections are widely used : radiography, ultrasonics, eddy currents, etc. The choice of an inspection technique is made on the basis of different criteria : type of material to be tested, type of defects sought, detection or characterization, inspection time and cost. In some cases, either to compare the capabilities of different techniques, or to use complementary inspection methods, the same components are examined with different procedures. In these cases, it is very useful to have a single evaluation tool allowing direct comparison of the methods. This tool is indispensable for directly convoluting signals from two inspection methods.

PROCESSING

There is an increasing use of computer processing in inspection methods ; data acquisition is digitized and the large amount of information from the probes requires sophisticated processing. This type of acquisition allows new analysis possibilities by suitable use of imaging and processing of the image or its associated signal. These images make it possible to represent defects in the inspected component, and the software can improve the signal to noise ratio and the detection and characterization of faults and materials. To reach these objectives, this signal software must be adapted to the inspection problems.

MODELING

The significant progress made in the modeling field must be emphasized. With some inspection methods, for example ultrasonics, detection is easy, on the other hand, the information has only an indirect relationship to the shape and size of the defect. In this case, the contribution of modeling is to deduce, using physical models, the defect from the data (reverse method). Modeling thus turns out to be a simple method for assisting analysis and can be coupled to highly advanced systems, though "user-friendliness" must be retained.

CIVA

The CIVA software program was developed to respond to these different requirements and constraints. It is the result of a collaboration between different CEA laboratories (Ultrasonic Inspections Laboratory, Electromagnetic Methods Inspections Laboratory, Ionizing Radiation Applications Branch, Neutronography Laboratory), with which several university laboratories are associated. In addition, the development of CIVA was facilitated by the experience gained in constructing the SPARTACUS system [1].

CIVA is an open system for processing NDE data. It is adapted to a standard work station (UNIX, C, MOTIF) and can read different supports on which the digitized data are stored. It makes it possible to obtain at the same time two or three-dimensional imaging, a representation combining several NDE techniques and image superpositioning. It includes a large library of signal and image processing methods accessible and adapted to NDE data (filtering, deconvolution, wavelet, transformation, correlation, segmentation, 2D deconvolution, 2D and 3D spatial correlations ; etc.). Different CEA and university modeling softwares (MEPHISTO, CHAMP-SON, MOTUS) are, or are being, integrated in the system. A block diagram of the ensemble of the utilities connected to the system is shown in Figure 1.

This advanced workstation can be adapted to different uses : for the laboratory, the wide possibilities offered allow easy development for a specific inspection, to produce special modules adapted to complex problems and to compare different methods. The system can subsequently be fixed to a specified configuration for industrial applications, an example is given in [2]. In other words, the system can be adapted to individual inspection cases; for selection of the most suitable imaging, processing or modelling for the problem, report editing, integration of inspection procedures, expertise.

Different CIVA capabilities are presented in some publications : signal processing adapted to coating inspections [3], image processing applied to coarse-grained material inspections [4], industrial applications for in-service inspection of pressurised water reactors [2]. Here, we will give only a few examples of technique comparisons.

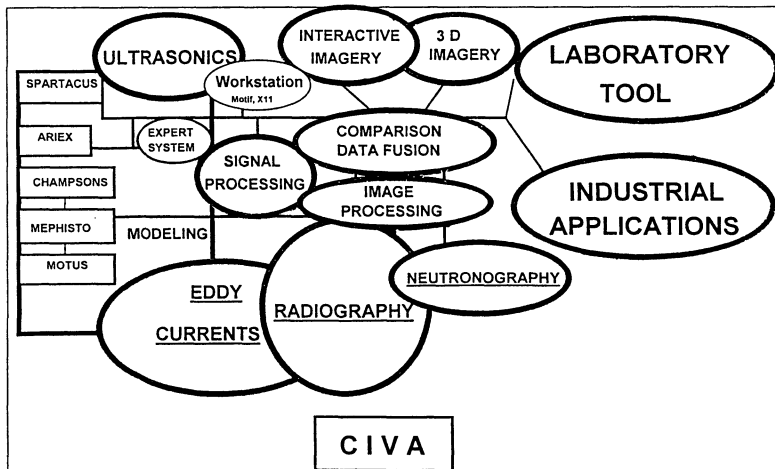


Figure 1. CIVA components, operations and applications

BRAZING INSPECTION

The first application example is inspection of a brazed brass joint. It can be seen that there are appreciable areas where the metal was not wetted. The inspection was made both by neutronography and longitudinal ultrasonic waves at 0° (Fig. 2). It is possible to visualize the CSCAN image from the ultrasonic inspection (view from above) along with the corresponding neutronography image (Fig. 3). It is then possible by image processing to extract the indication contours (Fig. 4) and show a direct superposition of the results (Fig. 5). Thus, the system can process files with data from different techniques and show data of the same type in the same image.

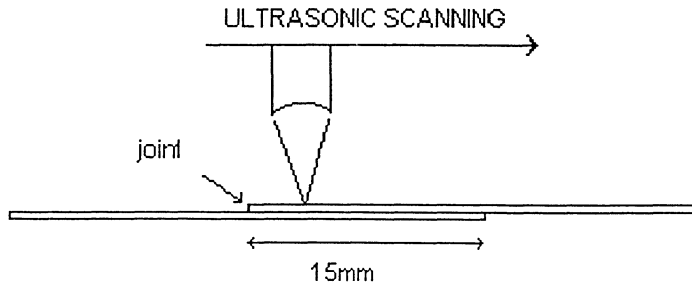


Figure 2. UT inspection of a brazed brass joint

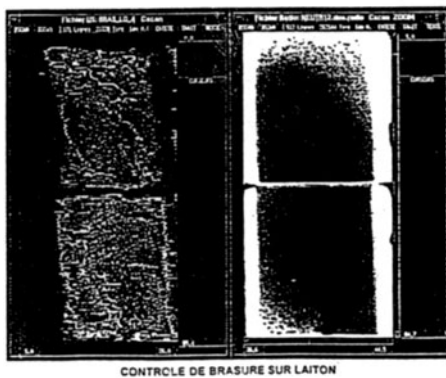


Figure 3. UT (CSCAN) imaging and neutronography

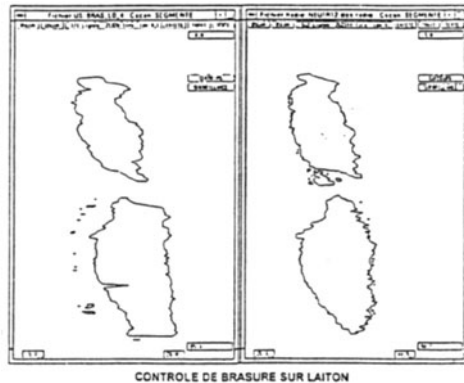


Figure 4. Contour extraction

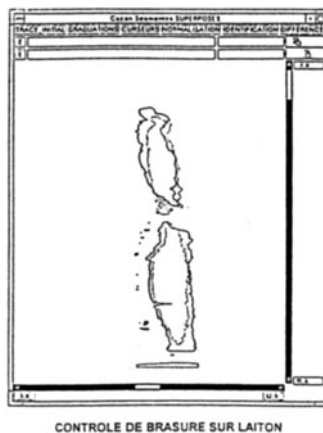


Figure 5. Superposition of UT and neutron images

TUBE INSPECTION

Inspections of steam generator tubes can be carried out by eddy currents and by ultrasonic waves by using a rotating probe in both cases. The example given is a 1.5 mm thick tube with standard type cracking (stress corrosion). Mapping of the tube (with the angular position as abscissa) can be obtained from eddy current (Fig. 6) and ultrasonic wave data (Fig. 7). As in the above example, we can shift and superpose the signal envelopes from the two techniques (Fig. 8) and use the ultrasonic BSCAN cross sections to give the crack dimensions in the tube wall.(Fig. 9). Other types of images are possible, in Figure 10 the tube geometry from results of an eddy current inspection is displayed. Utility programs make it possible to visualize the tube from different points of view. This example shows how inspection techniques can truly complement each other.

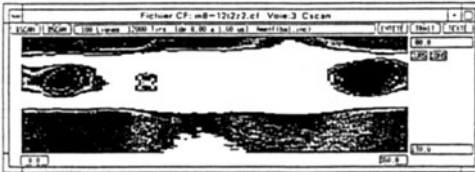


Figure 6. Eddy current mapping (tube)



Figure 7. UT CSCAN tube image

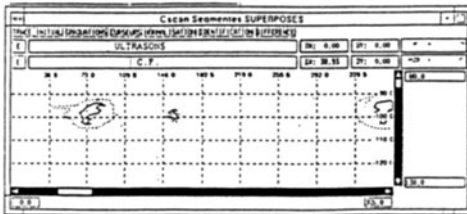


Figure 8. Superposition of UT and EC images

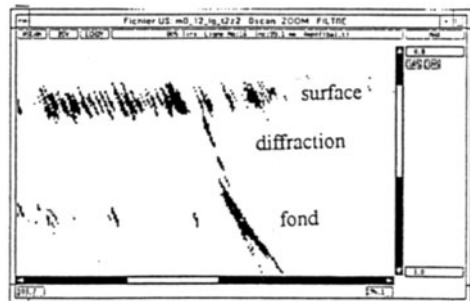


Figure 9. Measurement of defect dimensions

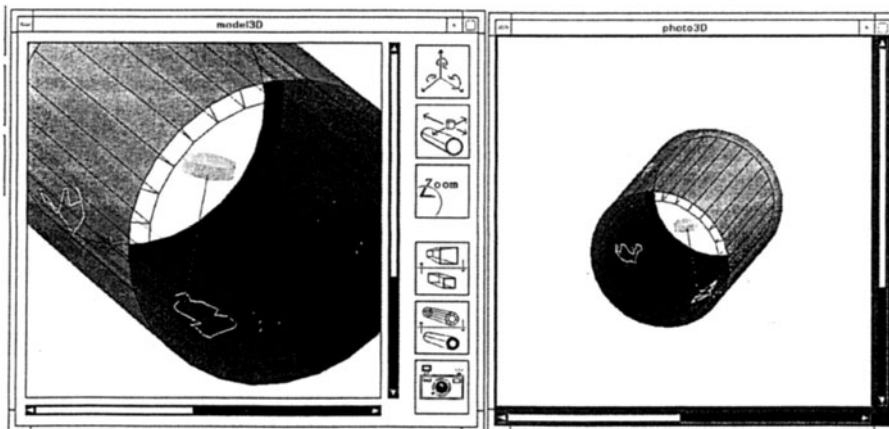


Figure 10. 3D visualisation of an EC tube inspection

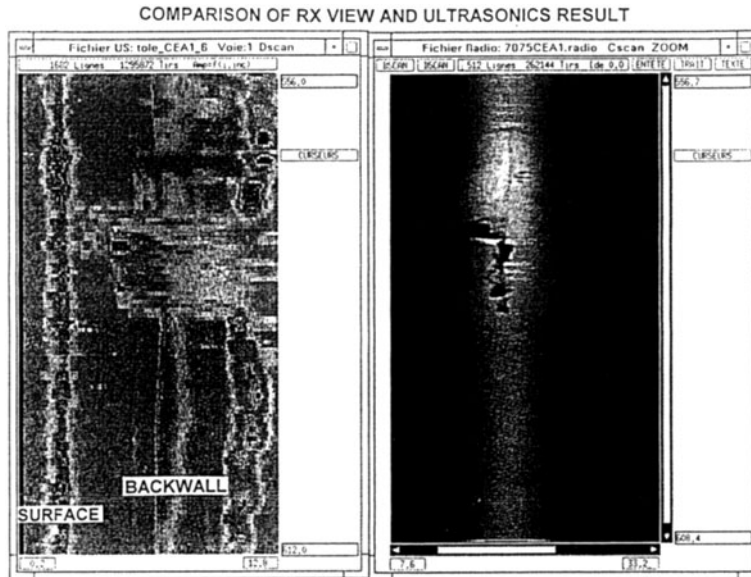


Figure 11.

ALUMINIUM WELDS EXAMINATION

The new generation of cryogenic tank for the ARIANE program leads to an evolution of the non destructive methods [5] : a cooperation program between CEA and AEROSPATIALE has been conducted in order to evaluate the capacity of an ultrasonic examination and to develop an automatic system for treatment and analysis. In order to evaluate the method a cross comparison has been conducted between UT performances and radiography. On the figure 11, we compare directly on a defect radiography with a DSCAN ultrasonics image (side views). This permits to see, on this example, the localization of the defect in through thickness of the weld.

DIRECT COMPARISON OF MODELLING AND EXPERIMENTAL RESULTS

Now, let me see how some modeling results can be handle by the system. Currently two models are developed at the CEA in the ultrasonics domain. Firstly the CHAMP-SON code allows to calculate the field in a material with different possibilities of probe's design, material's geometries ; this model is fully described in [6]. Beside the scientific background linked to a model, it is essential that this kind of model can be operate by non specialist. A very easy operator interface helps the operator to set up the paramaters. Images issued from calculation are produced (fig. 12) and the calculated images (bean profile, calculated ASCAN, field map...) can then be directly handle by CIVA and superposed into the system, to compare experimental beam measurement and calculation.

A second model, named MEPHISTO is dedicated to interaction between a beam and a defect. This model is described in [7]. It allows to predict echoes provided by diffraction, reflection, corner effect, and mode conversion, and to display images corresponding to those obtained during acquisition. When a thick weld (200 mm) is inspected by transverse ultrasonic waves at 45° (Fig. 13) and if we wish to have the dimensions of a defect near the outside wall, the BSCAN image

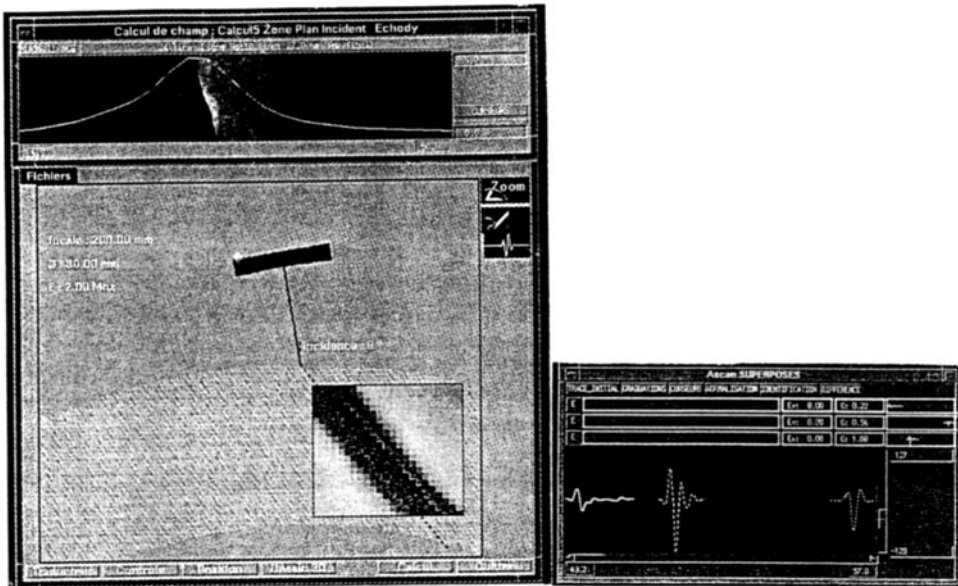


Figure 12. Champ-Sons : results of calculations

obtained is complex due to the significant corner effect. With the different CEA software modeling programs (MEPHISTO, CHAMPS-SONS), the phenomenon can be described and the corresponding inspection simulated. Thus, for a 10-mm high lack of fusion located at 10 mm from the base, CIVA allows simultaneously the visualization of (Fig. 14) the calculated and the experimental BSCAN. After segmentation of the two above images (Fig. 15) the experimental results can be directly superposed on the modeling (Fig. 16). This is a good example of the advantages that modeling can provide.

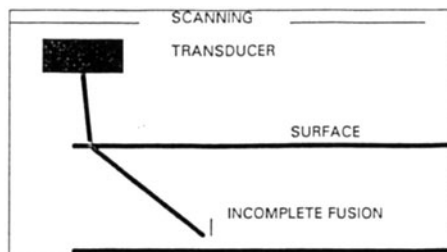


Figure 13. Inspection of defect near the outside wall



Figure 14. Computed and experimental BSCAN images



Figure 15. Segmentation of BSCAN images

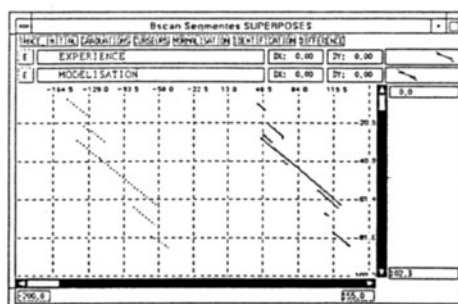


Figure 16. Superposition

CONCLUSION

The first applications of CIVA show the advantages of a dedicated advanced work station for Non Destructive Tests. The integration of numerous processing imaging and modelling functions and the possibility of simultaneously processing data from complementary techniques in an open system markedly improve inspection results. The modular nature of CIVA allows envisaging its application both in the laboratory and in industry with a fixed configuration.

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