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Application of Photon Tomography to Weld Inspection

Application de la tomographie par photons au contrôle des soudures

Anwendung der Photon-Tomographie zur Kontrolle von Schweissnähten

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SUMMARY
The results of a study of the application of photon tomography to weld inspection are presented. The evaluation of two weld cores containing defects is presented and compared with standard radiography. The results indicate that tomography may be an extremely useful method of weld inspection.

RESUME
Les premiers résultats d'une étude de l'application de la tomographie par photons au contrôle des soudures sont présentés. L'examen de deux échantillons soudés contenant des défauts a été effectué par ce procédé et comparé à celui effectué par la radiographie habituelle. Les résultats indiquent que la tomographie peut être une méthode extrêmement utile pour le contrôle des soudures.

ZUSAMMENFASSUNG
Die Resultate einer Untersuchung von Schweissstellen mit der Methode der Photon-Tomographie werden vorgestellt. Zwei defekte Schweissungen werden mit Hilfe der neuen Methode beurteilt und die Resultate mit denjenigen der Röntgen-Methode verglichen. Der Vergleich lässt darauf schliessen, dass die Photon-Tomographie eine äusserst nützliche Methode zur Kontrolle von Schweissnähten ist.

1. INTRODUCTION

The purpose of inspecting weldments nondestructively is to ensure that weldments do not contain defects which will cause the welds to perform unsatisfactorily. The fatigue performance of a full penetration butt weld with its reinforcement round off is governed by the size of the internal defects in the weld and the stress range it will be subjected to in service. Most inspection specifications contain a statement requiring that welds which contain sharp crack-like planar defects, such as lack of fusion, inadequate penetration, and cracks, be rejected. This requirement is based on the reasoning that these sharp planar defects will produce welds with short fatigue lives compared to welds containing small amounts of porosity and slab inclusion. However, it must be understood that for each type of inspection technique there is an associated detection level and resolution level. For example, ultrasonic inspection techniques can easily detect very small defects of the order 1 to 2 mm, but cannot easily resolve, determine the size and shape, defects this size.

This paper presents the preliminary results of a research project sponsored by the Federal Highway Administration, Office of Research, to determine the feasibility of using photon tomography for the inspection of weldments. A laboratory scanner is used to determine the detectability and resolution of tomography. The results will be compared with ultrasonics (U.T.) and radiography (R.T.) testing to determine the value of tomography relative to these existing inspection methods.

2. TOMOGRAPHY TECHNIQUE

The tomography technique consists of taking a series of radial views around an object to construct a two-dimensional image of the object perpendicular to the viewing plane. Normally a collimated system is used which restricts the area to be imaged to a narrow slice through the object. The resulting two-dimensional image or tomogram is a graphical representation of the object's opacity to the interrogating source.

A comparison of the information obtained from computerized tomography (CT) and RT inspection of a butt weld is shown in Fig. 1. The defect geometry in the slice plane is obtained in the tomogram while the radiograph yields only the length of the defect. The image of the defect in the tomogram allows the significance of the defect to be rationally assessed.

The tomography scanner used in this study is described in detail in Ref. 1. Briefly, it consisted of a gamma ray isotope source, a rotating table for the object to be examined, and a photon counting detector array. The gamma ray source is placed opposite the detector array, with the object in the center, as shown in Fig. 2. The object is rotated to produce major positions and the detector array moved a smaller amount for minor subpositions. The detector array consists of 31 fast plastic scintillators coupled to photomultiplier tubes. The digital output of the photomultipliers is stored and subsequently analyzed in a PDP 11/35 computer. The tomogram is produced by employing the filtered back-projector analytical method.

The tomograms shown in this paper were produced with a ^{60}Co source. A 2 mm aperature is used at both the source and detector, yielding an effective slice plane thickness of 2 mm.

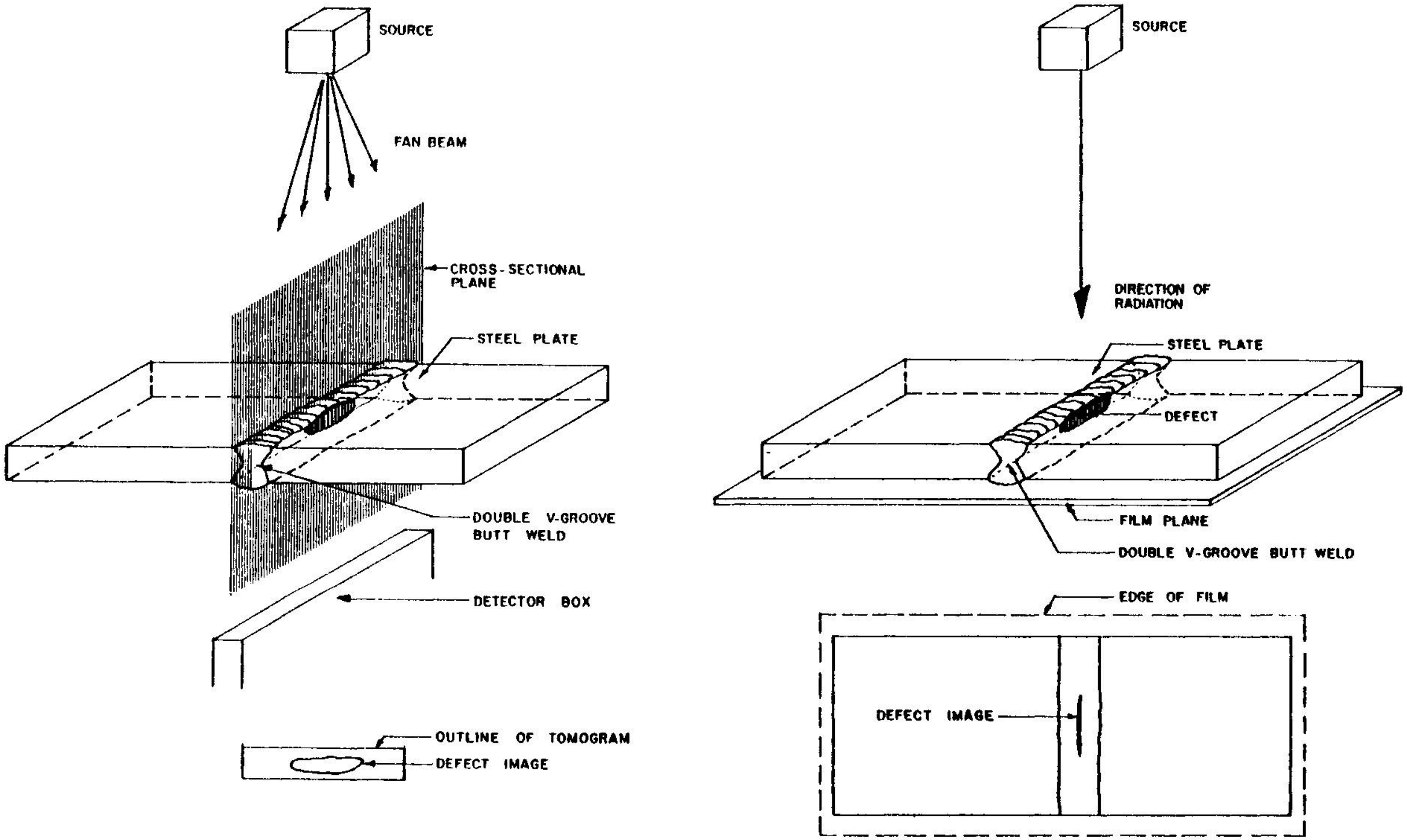

Fig. 1 Defect Imaging with CT and RT

3. EXPERIMENTAL VARIABLES

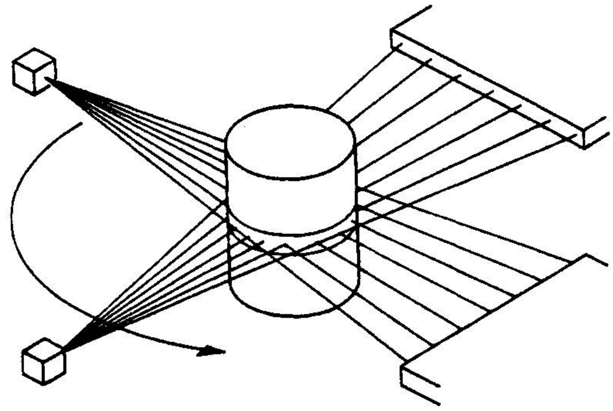

Fig. 2 CT Scanning Process (Courtesy of Scientific Measurement Systems)

The applicability of CT to weld inspection is being determined by inspecting cores removed from in-service bridges, laboratory fabricated welds made with a variety of purposely introduced defects, and control specimens called phantoms containing carefully machined adjustable voids. The influence and interaction of beam height (slice plane thickness), defect dimensions both in and out of the slice plane, partial view data caused by lack of transmission in rectangular objects, and scanning increments upon the sensitivity of the method. The results of the study on weld cores containing sharp cracks from an in-service bridge are given in the next section.

4. EVALUATION OF TOMOGRAPHY USING WELD CORES

Weld cores from the Silver Memorial Bridge located at Point Pleasant, West Virginia, U.S.A., were scanned as part of a study to determine the significance of the cracks found in a field inspection of the bridge. The details of the study are given in Ref. 2. The results of two weld cores are detailed below.

Many of the cores from the bridge had visible cracks at the edge of the weld. These welds were butt welds used to join the plates comprising the flanges of the "H" shapes used for the members of the truss. A typical example is shown in Fig. 3. The edge of the weld, at the flange tip, contains two large defects. Standard radiography of the cores, at 1% sensitivity, did not image these large cracks. A tomogram was taken of the core perpendicular to the face shown in Fig. 3. The results are shown in Fig. 4. Both defects are imaged. The curved shape and depth of the upper defect was confirmed by destructive examination.

In another core, a defect was found by radiography. An internal defect was interpreted as porosity by the radiographer. A tomogram across the weld at the defect produced the results shown in Fig. 5. Figure 6 shows a cross section of the weld at the location of the tomogram slice plane. The defect imaged in the tomogram agrees with the results of the destructive examination. The defect is not porosity but a fusion line defect.

5. CONCLUSIONS

The results of these two cores indicate that the sensitivity of tomography exceeds radiography and provides a much easier to interpret image. Further work is underway to evaluate tomography with other weld defects and phantoms. The results to date indicate tomographic inspection of weldments is a potentially very useful and powerful technique.

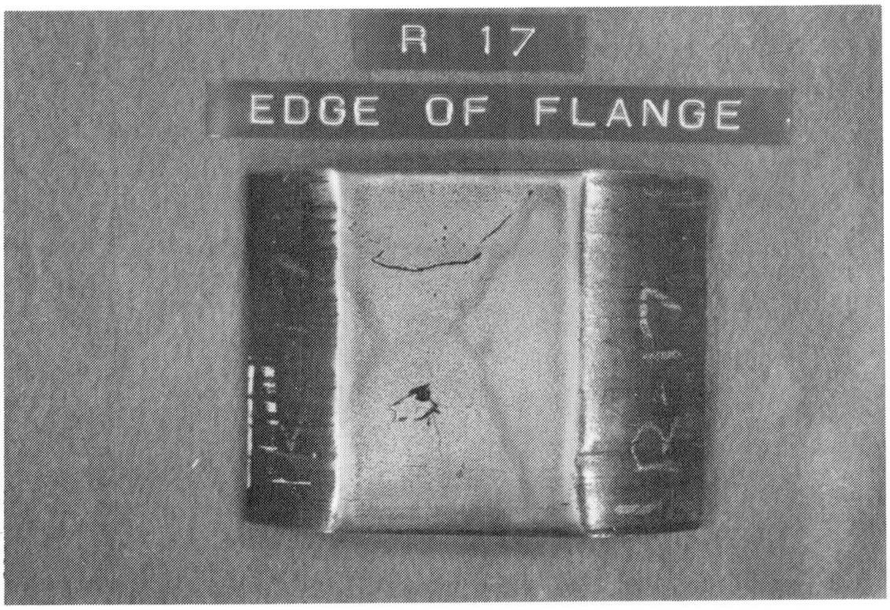

Fig. 3 Edge of Core Showing Two Defects

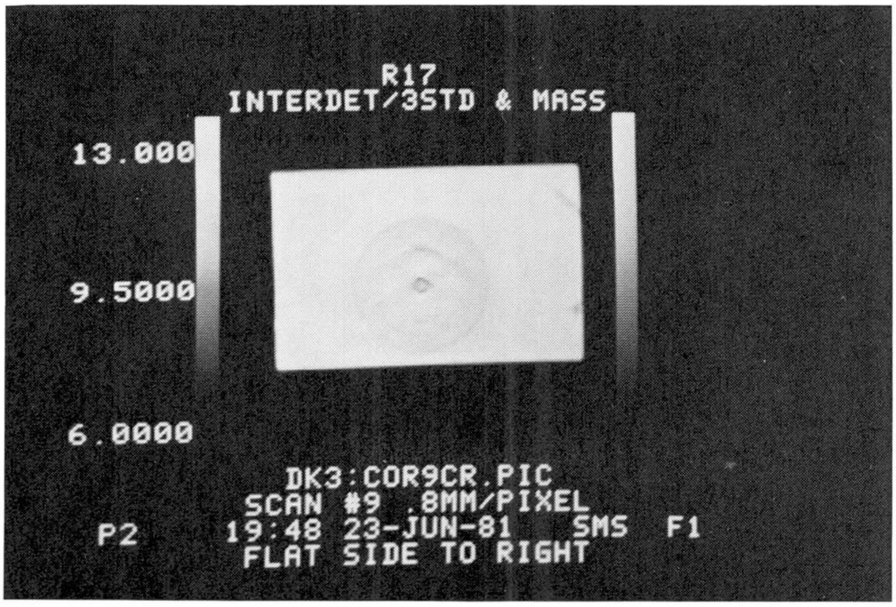

Fig. 4 Tomogram Through Edge Defects

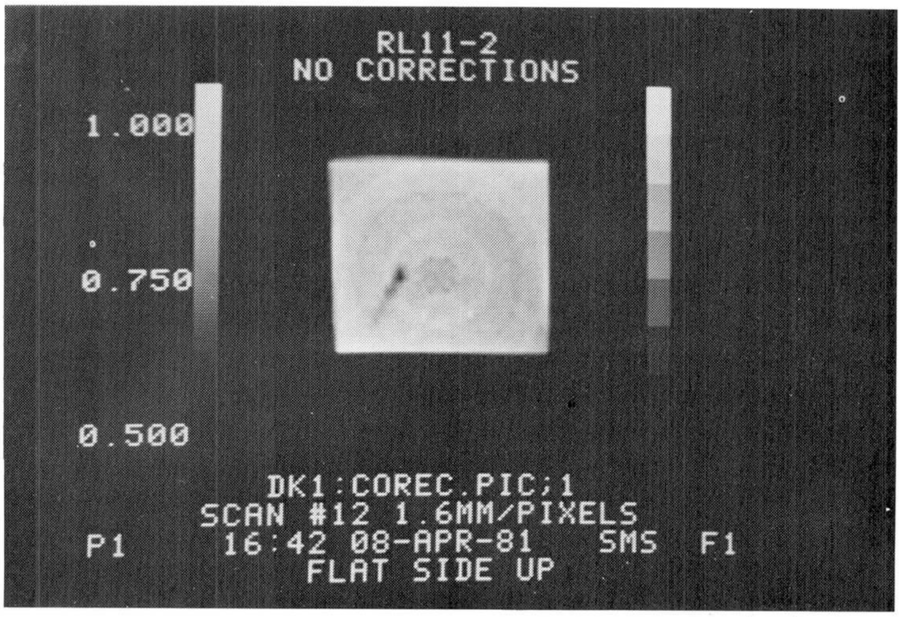

Fig. 5 Tomogram of Embedded Defect

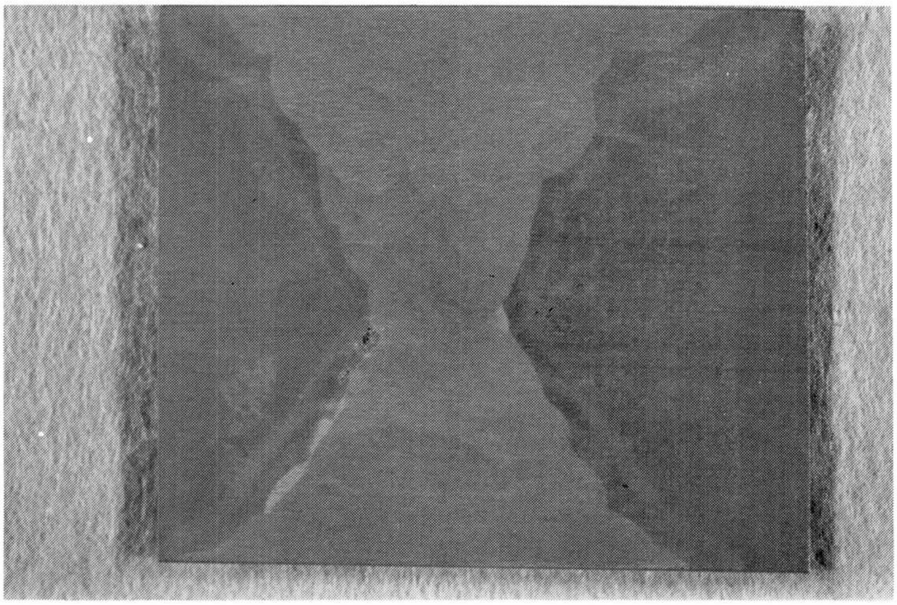

Fig. 6 Cross Section of Weld at Embedded Defect

REFERENCES

1 ELLINGER, H., et al, "Tomographic Analysis of Structural Materials," Proceedings of the Society of Photo-Optical Instrumentation Engineers, Vol. 182 - Imaging Applications for Automated Industrial Inspection and

2 FRANK, K. H., and COLWELL, A. B., "Evaluation of Silver Memorial Bridge - Phase III - Weld Metal Core Evaluation," PMFSEL, U. of Texas at Austin, July 1981, PMFSEL-WV-2.