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CEA-CONF-- 8882

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ULTRASONIC EXAMINATION OF DEFECTS CLOSE TO THE OUTER SURFACE

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Communication présentée à : 8. International conference on nondestructive evaluation in the nuclear industry
Orlando, FL (USA)
17-19 Nov 1986

ULTRASONIC EXAMINATION OF DEFECTS CLOSE TO THE OUTER SURFACE.

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-INTRODUCTION-

During the examination of a pressurized water reactor vessel with an in Service Inspection Machine (MIS), various welds are scanned with immersion ultrasonic focused transducers from the inside of the vessel.

Defects close to the outer surface are sometimes detected, and sizing with the successive 6 dB drop method leads to oversize some indications ; this is caused by various reflections on the outer wall ; the corner echo is of particular importance here.

CEA and EDF have started an experimental program in order to study the response of volumetric and planar defects located near the outer surface. We present here the first results obtained with artificial defects.

-EXAMINATION METHOD-

The tests have been conducted on a block (thickness 200 mm) containing various artificial defects : side drilled holes of different diameters ; slag inclusions ; lack of fusion, notches of various heights. By machining the test block, the distance of the volumetric defects to the outer surface has been varied (from 20 mm to 5 mm).

This test block is immerged in a pool and the examination is performed with an X-Y laboratory scanner, associated to a digital acquisition system (STADUS [1]) and to an analog BSCAN equipment [2]. The focused probes used are 45° and 60° shear wave, 1 megahertz transducers. The focal beam diameter of these transducers is about 10mm. The examination method is shown on figure 1. BSCAN images which are presented in this paper are analog BSCAN views. Destructive examination of the block permits comparison between experimental BSCAN and macrography of the defects.

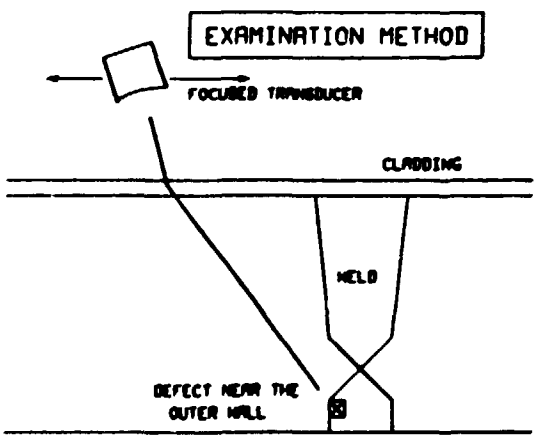


FIG. 1

-EXPECTED BSCAN IMAGES-

Some examples of BSCAN images are given for a 45° shear wave transducer on figures 2 and 3 : the two figures correspond to a side drilled hole located from the outer wall at distances respectively smaller and greater than the focal beam diameter. BSCAN images are composed of several linear segments, each of which arising

from a specific ultrasonic path. Each individual segment has to be perpendicular to the incident wave front. The main encountered echoes are the direct echo, the echo after reflection and the corner echo (on the figures mode conversion echoes have not been represented).

EXPECTED BSCAN IMAGE

- 2 MM SIDE DRILLED HOLE
- 45° SHEAR WAVE TRANSDUCER

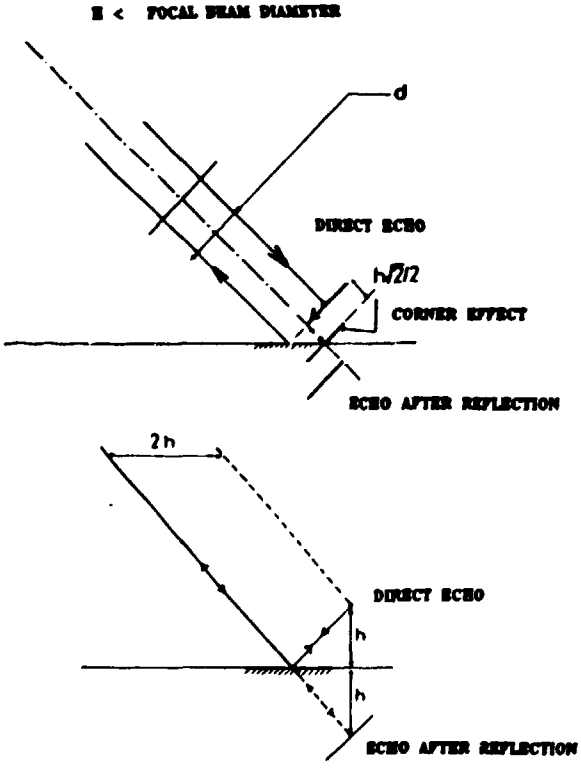


FIG. 2

EXPECTED BSCAN IMAGE

- 2 MM SIDE DRILLED HOLE
- 45° SHEAR WAVE TRANSDUCER

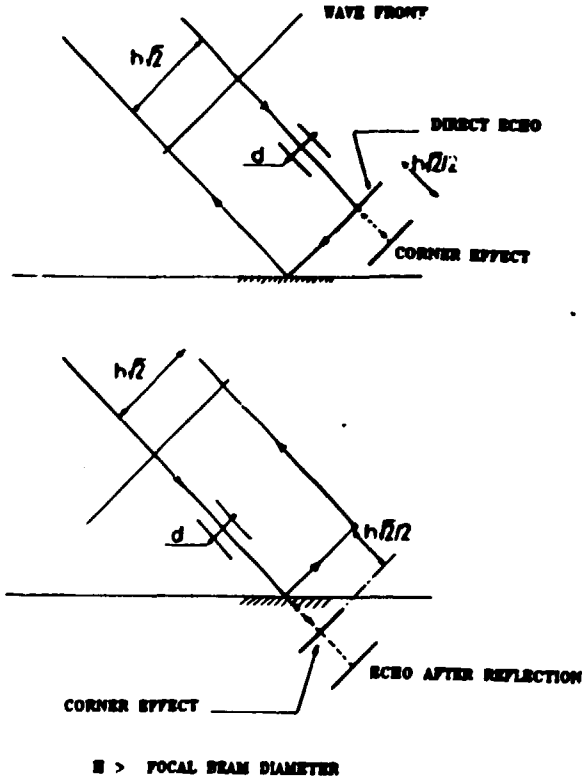


FIG. 3

When looking only at the corner effect echo, we observe either a single corner echo centered on the theoritical corner position or two segments corresponding to two peaks located in the direct echo axis and in the axis of the echo after reflection.

-EXPERIMENTAL RESULTS-

Experimental results confirm these assumptions. On figure 4 we can see the ultrasonic image of a 2 mm side drilled hole. This BSCAN view corresponds to the figure 2.

EXPERIMENTAL BSCAN FOR A 2 MM SIDE DRILLED HOLE

R=15 MM

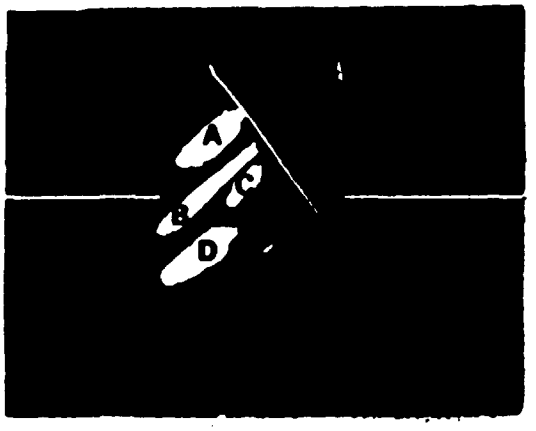
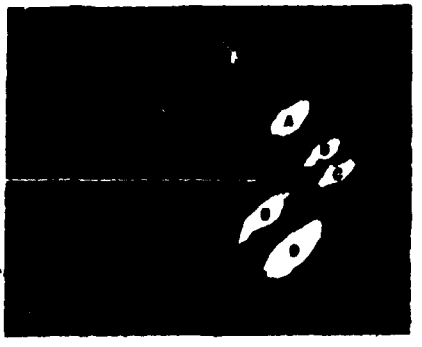


FIG. 4

On figure 5 we present ultrasonic response of a slag inclusion in comparison with macrography of this defect. This slag has the same kind of ultrasonic behaviour as the hole. We remark for this BSCAN view that corner effect appears in two separated parts.

COMPARISON BETWEEN MACROGRAPHY AND EXPERIMENTAL BSCAN



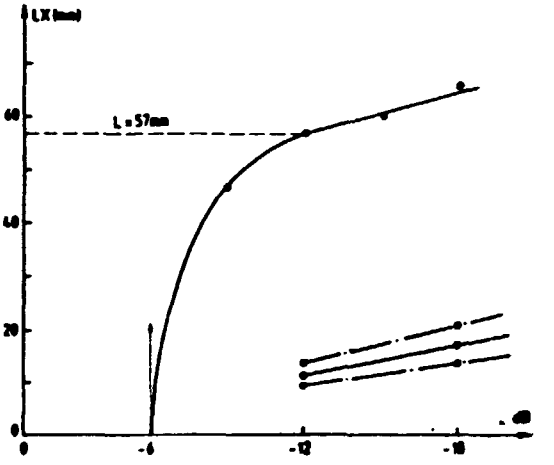
Slag

FIG. 5

For this slag, the conventional sizing method using 6 dB drop step by step gives : Lx = 57 mm (figure 6) when the true value is 9 mm, this oversizing is due to the corner effects and the echo after reflection that are taken in account on CSCAN images.

SIZING CURVE

I.S.I SIZING PROCEDURE WITH THE SUCCESSIVE 6 DB DROPS METHOD

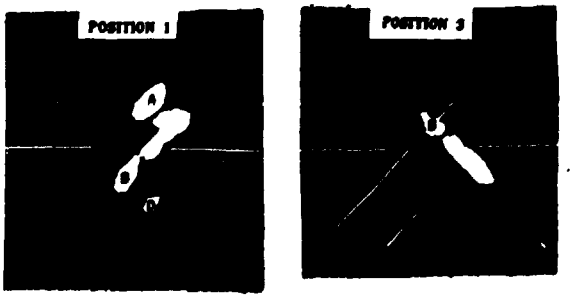


EXAMPLE OF OBTAINED RESULT FOR A 5 MM SLAG LOCATED AT 15 MM OF THE OUTER WALL

FIG. 6

Figure 7 shows a lack of fusion ; we can notice on the right side of the view (corresponding to one of the scanning direction) that the defect appears only through its corner effect echo.

COMPARISON BETWEEN MACROGRAPHY AND EXPERIMENTAL BSCAN



LACK OF FUSION

FIG. 7

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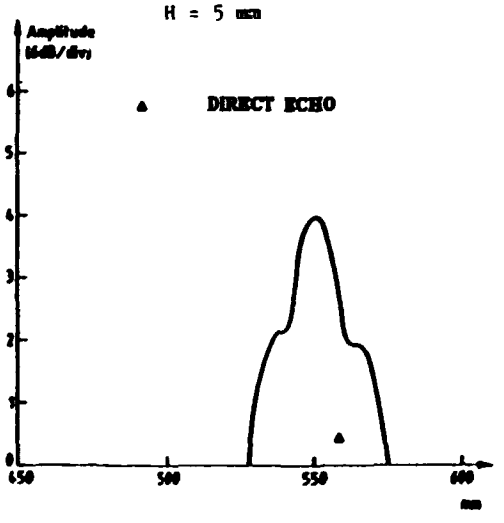
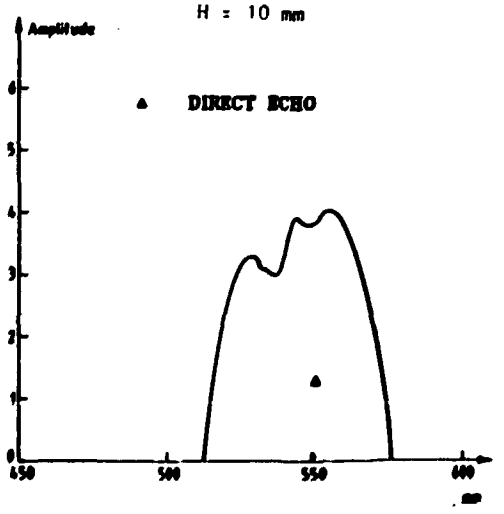
When machining the block by step of 5 mm, we simulate a defect located at various distances from the outer wall. Looking only at the corner effet echo, the amplitude as a function of the displacement is drown for three distances from the wall (figure 8).

CORNER ECHO AMPLITUDE FUNCTION OF DISPLACEMENT





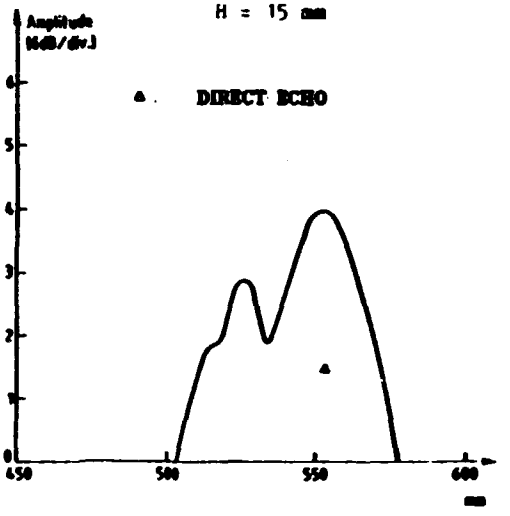


FIG. 8

The expected BSCAN are confirmed : for a small distance from the uter wall, the curve presents only one peak (centered on the outer wall) and for larger distance, two peaks corresponding to the position of direct echo and the echo reflection.

-CONCLUSION-

The first experimental results of this program shows up different points :

- a simple CSCAN image analysis is unable to size properly the defect
- BSCAN image explains the observed oversizing by the presence of various echoes
- An accurate method to evaluate is determined, either by the scanning difference of two echoes (direct and after reflection) or only by measurement of peaks position on the echodynamic curve.

This program is still continuing with the study of the ultrasonic response of cracks located near the outer surface.

-BIBLIOGRAPHY-

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