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CONTRIBUTIONS TO NONCONTACT ULTRASONIC EXAMINATION OF COMPOSITE MATERIALS USED IN CIVIL AND INDUSTRIAL CONSTRUCTION

G. Amza[1] , C. Florică[1], G.D. Taşcă[1], I. Ciobanu [1]
Polytechnic University of Bucharest, Romania, amza@camis.pub.ro

Abstract: *During operation of a commercial or industrial structure several defects may occur: micro cracking and cracking of resistance elements due to fatigue, corrosion of columns and beams and others; earthquakes may contribute to degradation of electrical installations and embedded piping.*
This paper presents a method of non-contact ultrasound for the determination of such defects in beams, fittings and embedded pipes.
Keywords: *ultrasound, non-contact, examination, pipes, structures*

1. INTRODUCTION

The main defects that may arise or affect any civil or industrial construction are defects in the installation, material defects and operational faults | 1 |, | 2 |, | 3 |.
If earthquakes occur under the action of important physical wear demands on materials that are part of the resistance structure (internal cracks and fissures, breaks and damage resistance pillars and beams, cracking the plates and beams, joints in masonry or between masonry and plates embedded piping degradation, degradation of electrical installations etc..).
Most of the defects listed above can be highlighted using ultrasound method in several ways: pulse reflected and transmitted pulse echoes repeated.
During operation of a commercial or industrial structure may show up a number of defects: micro cracking and tear resistance elements due to fatigue applications, corrosion of reinforcement in columns or beams of resistance and other defects that are very difficult to determine the classical technologies. Ultrasound methods have a number of disadvantages, related to very high sensitivity of that method, the need for an acoustic coupler, essential dependence on operator interpretation of results and failure control by two or more opposite sides of a wall, beam or column.|3|
To remove some of these disadvantages, the research contained in this doctoral thesis try to combine with another method ultrasonic nondestructive investigation - thermography infrared - and to propose a new technology for investigation and control without contact between the object and instrument control .

2. TECHNICAL REQUIREMENTS

Since the acoustic coupling problem is difficult to solve the investigation of civil and industrial construction elements, the issue of using air to achieve acoustic coupling between the ultrasonic transducer and controlled environment.
Because attenuation of ultrasound in air, in MHz is very large compared to the medium investigated, i.e. when ultrasound moves from an environment with very low acoustic impedance, acoustic impedance in an environment with very high only a fraction of ultrasonic energy is transmitted in rural investigated. Transmission coefficient T, the ultrasonic transducer investigated environment is determined by the relationship:

$$T = 4\frac{Z_1 Z_2}{\square}(Z_1 + Z_2)^2 \qquad (1)$$

where: Z1 is the acoustic impedance of the ultrasonic carrier environment (eg air non-contact control) and Z2 - acoustic impedance test environment.
Transmission coefficient is defined as the ratio of transmitted acoustic energy V (measured in volts) and V0 input energy, it is refracted longitudinal wave at the angle of incidence of 0 ° on the interface between the two areas, namely|2|:

$$\mathbf{T} = \frac{\mathbf{V}^2}{\mathbf{V_0}^2} \qquad (2)$$

This relationship can be described as logarithmic scale:

$$\mathbf{T} = {}^{20\log V}\!/_{V_0}\ [\mathrm{dB}] \qquad (3)$$

So, the energy transferred to propagation medium Et is calculated by the formula:

$$\mathbf{E_t} = \mathbf{20\log T} \qquad (4)$$

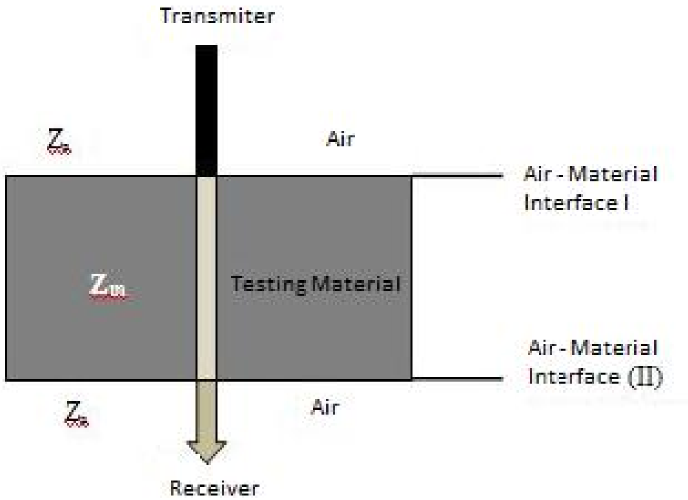

Figure 1: Areas to be traversed by ultrasound (shown by arrow) in non-contact mode of transmission ultrasound to propagate through a material testing.
Area "I" corresponds to air-material transmission (acoustic impedance Za of the Zm) and the surface "II" corresponds sending material to air (acoustic impedance Zm of the Za).

Ultrasound for non-contact examination must be spread in the air in the test material and then again in the air so that the transmitted wave can be detected by a receiver (Figure.1). Therefore, high energy loss at the air-material loss is accompanied by additional material-air interface.|3|,|4|,|5|
In relative mode, the attenuation of ultrasound in air is intrinsically higher in comparison with attenuation of solids or liquids. Since attenuation increases in an environment based on the fourth power of the frequency, transmission megahertz frequency ultrasound with air becomes almost impossible.
Effectiveness of an ultrasonic transducer coupling coefficients depend on other electromechanical properties of piezoelectric material. Also depends on the mechanism by which ultrasound piezoelectric material is transferred from the environment should be propagated ultrasound. Non-contact mode, this medium is air. Since the acoustic impedance of the piezoelectric material is a few degrees higher magnitude than air, it is usually necessary to insert the transition layer (suitable acoustic impedance) of different materials before piezoelectric material.
Finally, the last layer characteristics determine the transduction efficiency of a transducer device. Significance final acoustic impedance matching layer of non-contact transducers cannot be overstated. Since the piezoelectric properties of a given material can be considered constant for a given device, the final transfer of ultrasonic energy in the air is wholly controlled acoustic characteristics of the final layer piezoelectric material adapted.
Because ultrasound transmission in air to be as close to the truth, the final layer should be composed of piezoelectric polymers fine. Polymer layer that builds these transducers can be porous or non-porous and can be embedded inside hollow spheres (the polymer layer). To simplify, we will identify all polymers suitable acoustic impedance transducers using an air gap. These transducers emit ultrasound in air at -58 ... -54 dB, which corresponds to the propagation of ultrasound in some parts ~ 2 MHz contactless method. Using this non-contact transducers with final layer of a polymer built a stand that experimental measurements were made on several material (Fig. 3), SECU-01FC model.

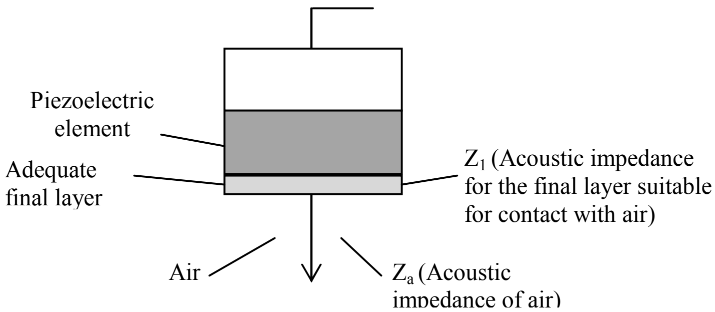

Figure 2. An ultrasonic transducer diagram indicating adequate final layer of acoustic impedance relative to critical and piezoelectric coupling medium, air.

3. EXPERIMENTAL CONTRIBUTIONS OF THE ULTRASOUND EXAMINATION OF BURIED PIPELINES THROUGH WHICH THE FLUID PRESSURE

Examination or monitoring of corrosion / erosion, to establish lifetime of pipes through which the fluid at different temperatures and / or pressure is a very important activity for both the designer and the owner, because knowing 'health "their time is extremely important. Existence of defects possible occurrence of cracks can lead to accidentally run out, sometimes with serious consequences and most significant damage. Therefore periodic examination of buried piping systems or by circulating different fluids (water, air, gas, steam) at different temperatures and pressures is required to know the life and establish the necessary measures to prevent various accidents.

For testing were chosen most important parts of a pipeline where possible occurrence of defects and where corrosion may be greater. Thus, we have established methods of examination for parts such as elbows to 900, sections of pipe welded pipe portions reduction and seamless pipe. For elbow 900, made of OLT60 with nominal thickness of 10 mm, and the nominal diameter of 145 mm (Fig. 4) found the results shown in Table 1.

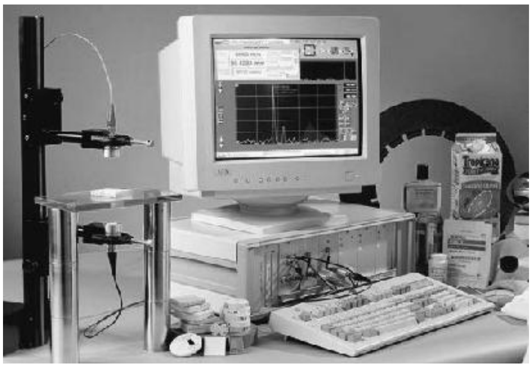

Figure 3: Stand SECU 01-FC experimental model of non-contact ultrasonic testing, which uses contactless sensors and a screen that displays the material thickness and speed testing

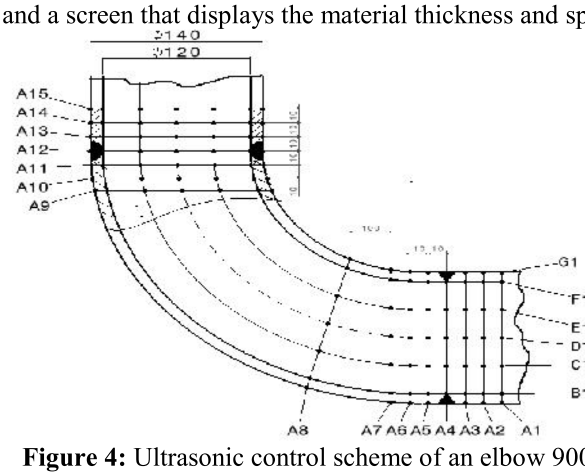

Figure 4: Ultrasonic control scheme of an elbow 900:
A1 ... A15, B1 ... B15, C1 ... C15, D1 ... D15, E1 ... E15, F1 ... F15, G1 ... G1

Table 1: Experimental results obtained from ultrasound examination of a side 900 (excerpt)

No. Crt.	Measuring point	Date of measurement	Thickness measured	The next	Thickness measured	Observations
0	1	2	3	4	5	6
1	A1	14.08.2010	9,54	20.08.2011	9,05	0,49
2	A2	14.08.2010	9,53	20.08.2011	9.01	0,52
3	A3	14.08.2010	9,95	20.08.2011	9,41	0,54
4	A4	14.08.2010	9,93	20.08.2011	9,37	0,56
5	A5	14.08.2010	9,47	20.08.2011	8,82	0,65
6	A6	14.08.2010	9,46	20.08.2011	8,93	0,53
7	A7	14.08.2010	9,52	20.08.2011	9,03	0,49
8	A8	14.08.2010	9,51	20.08.2011	9,12	0,39
9	A9	14.08.2010	9,52	20.08.2011	9,21	0,31
10	A10	14.08.2010	9,47	20.08.2011	8,97	0,50
11	A11	14.08.2010	9,92	20.08.2011	8,99	0,93
12	A12	14.08.2010	9,89	20.08.2011	9,28	0,61
13	A13	14.08.2010	9,74	20.08.2011	9,60	0,14
14	A14	14.08.2010	9,73	20.08.2011	9,28	0,45
15	A15	14.08.2010	9,48	20.08.2011	9,02	0,46
16	B1	14.08.2010	8,82	20.08.2011	8,40	0,42
17	B2	14.08.2010	8,83	20.08.2011	8,37	0,46
18	B3	14.08.2010	8,93	20.08.2011	8,17	0,76
19	B4	14.08.2010	8,90	20.08.2011	8,22	0,68
20	B5	14.08.2010	9,28	20.08.2011	8,75	0,53
21	B6	14.08.2010	9,26	20.08.2011	9,08	0,18
22	B7	14.08.2010	9,32	20.08.2011	8,88	0,44
23	B8	14.08.2010	9,66	20.08.2011	8,98	0,68
24	B9	14.08.2010	9,73	20.08.2011	9,13	0,60
25	B10	14.08.2010	9,17	20.08.2011	8,62	0,56
26	B11	14.08.2010	9,10	20.08.2011	8,56	0,54
27	B12	14.08.2010	8,95	20.08.2011	8,47	0,52
,,,	,,,	,,,	,,,	,,,	,,,	,,,
82	F7	14.08.2010	9,36	20.08.2011	8,86	0,50
83	F8	14.08.2010	9,42	20.08.2011	8,72	0,70
84	F9	14.08.2010	9,38	20.08.2011	8,68	0,70
85	F10	14.08.2010	9,28	20.08.2011	8,78	0,50
86	F11	14.08.2010	9,17	20.08.2011	8,93	0,24
87	F12	14.08.2010	9,42	20.08.2011	8,82	0,50

Table 1 (Continued)

88	F13	14.08.2010	9,31	20.08.2011	8,92	0,29
89	F14	14.08.2010	9,29	20.08.2011	8,62	0,67
90	F15	14.08.2010	9,12	20.08.2011	8,61	0,51
91	G1	14.08.2010	9,41	20.08.2011	9,06	0,35
92	G2	14.08.2010	9,37	20.08.2011	9,21	0,16
93	G3	14.08.2010	9,56	20.08.2011	9,32	0,24
94	G4	14.08.2010	9,22	20.08.2011	9,08	0,14
95	G5	14.08.2010	9,12	20.08.2011	8,93	0,19
96	G6	14.08.2010	9,17	20.08.2011	8,98	0,19
97	G7	14.08.2010	9,48	20.08.2011	9,17	0,31
98	G8	14.08.2010	9,53	20.08.2011	9,72	0,11
99	G9	14.08.2010	9,47	20.08.2011	9,32	0,15
100	G10	14.08.2010	9,46	20.08.2011	9,28	0,28
101	G11	14.08.2010	9,28	20.08.2011	9,01	0,27
102	G12	14.08.2010	9,33	20.08.2011	9,08	0,25
103	G13	14.08.2010	9,48	20.08.2011	9,17	0,31
104	G14	14.08.2010	9,53	20.08.2011	9,21	0,32
105	G15	14.08.2010	9,61	20.08.2011	0,32	0,29

4. CONCLUSIONS

The analysis results can be drawn the following conclusions:
- Elbow minimum thickness was measured at the point B3, which was 8.17 mm;
- In sections A1 ... G15, thickness of 9.12 was measured at point G5;
- Maximum corrosion occurred at the point E12, which was 0.93 mm result is explained because the heat affected zone, where there is already internal thermal stresses introduced during the welding process;
- Minimum corrosion G8 is the point where was 0.11 mm, resulting understandable because the point is in an area with no possibility of turbulence and possible impact without solid impurities entrained fluid.

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