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GENERATION OF SAW AND THEIR PROPERTIES IN MATERIALS OF LOW ACOUSTICAL IMPEDANCE AND HIGH DAMPING[1]

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In this work a transformer of Lamb waves into SAW is described. Rayleigh waves generated with the application of this transformer in some acoustically "difficult" materials were investigated. Their velocities were measured with high accuracy.

I. INTRODUCTION

The developement of SAW testing methods is an important matter not only due to the fact that they are usually not destructive. The great advantage of the above methods is the possibility to test one side of accesible objects, as, for example some relics. The aim of this work was the development of effective and easy method of SAW generation on arbitrary surfaces of solids and especially in some acoustically "difficult" materials as teflon, vinidure, bones etc. Particular attention was devoted to the above mentioned materials. One of the common reason of difficulties in the SAW generation in these materials is a great wave impedance difference between tranducer materials and the above mentioned materials. The problem of impedances matching was solved by the application of a special transformer of impedance [1].

II. DESCRIPTION OF THE TRANSFORMER

This transformer presented in Fig. 1 consists of a thin wedge "W" of a solid material in which the dependence of mode a_o of Lamb waves velocity relative to thickness is known [2]. Fortunately this dependence is similar for the typical metals. A transducer "T" prepared for the shear vibrations is bonded to the thicker end of the wedge so that it stimulates mainly the asymmetrical mode a_o of a flexural wave which propagates along the wedge. The propagation velocity V_L of such a wave depends strongly on a thickness, whose value V_L approaching the thin end of the wedge strongly decreases [2]. Due to this dependence the resulting impedance (a product of ϱ, v) along the wedge strongly decreases as well, and it is possible to match it with the impedance of the tested material.

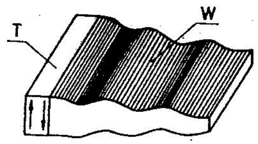

Fig. 1. The wedge which is the impedance transformer.

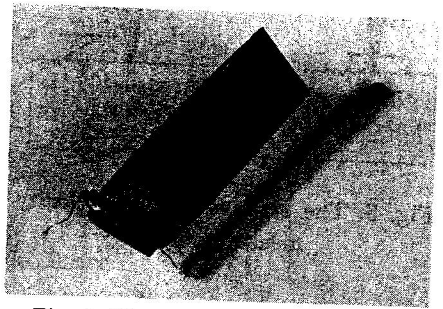

Fig. 2. The applied duraluminium wedge.

In our measurements of Rayleigh waves velocities a duraluminium wedge with a shear vibrating transducer of the frequency 0.5 MHz was applied. The applied transformer of impedance with the bonded, transducer and the match for comparison are shown in Fig. 2. The efficiency of SAW generation increases approximately from about 60 dB compared with the case of immediate touch of the shear vibrating transducer with the tested surface, with the same bonding material application in both cases. As a bonding material to improve the contact wedge edge – surface a non-hardened epoxy glue was applied with a better result compared to oil.

III. EXPERIMENTAL METHOD AND EQUIPMENT

As the source of electrical pulses a typical ultrasonic flaw unit (UFD - UNIPAN type 512) was used it served as a detector as well. The measurements were performed in an arrangement shown in Fig. 3.

A shear mode vibrating transducer stimulated by electric pulses from UFD generates a flexural wave propagating to the edge of the wedge. The edge performs vibrations in the horizontal direction and being in contact with the tested surface generates SAW in isotropic materials mainly of the Rayleigh type. On a similiar wedge edge a detection transducer is located (right part of the Fig. 3). On a side surface of the detection wedge a preamplifier (of high electrical input impedance and low output impedance) is located. The detected electrical signal is put into input of UFD. The electrical voltage respons from the detection transducer caused by the Rayleigh Wave (RW) pulse from the impedance transformer (IT) is presented in Fig. 4 (after detection). The position of the arbitrary given peak (GP)

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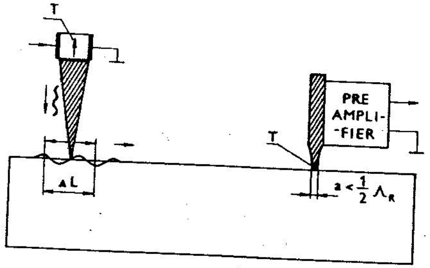

Fig. 3. The arrangement for velocity measurements.

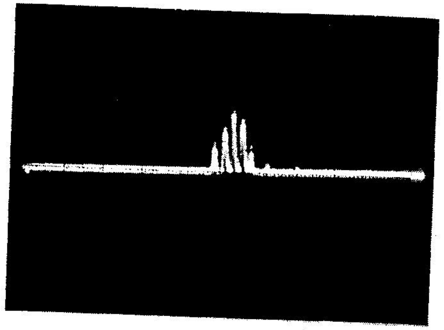

Fig. 4. The detected electrical response for the Rayleigh Wave pulse.

on the UFD screen can be measured with an accuracy of 0.02 mm owing to the application a microscope fixed on an $X - Y$ shift table with micrometers. This method was described in details before in [3]. Although the GP position can be established with an accuracy of 0.02 mm, the long time recurrence increases this limit up 0.04 mm, but this result can be regarded excellent. If we move IT backward or towards the detector, we observe the movement of GP on the screnn of the oscilloscope as well. After the IT edge displacement (along the emitter-detector direction) on the value ΔL, the GP position changes its value on Δt. Both values ΔL and Δt are measured in milimeters with the same accuracy 0.02 mm. The absolute values of Rayleigh waves (RW) velocities V_R can be calculated if we know Δt in seconds. This can be obtained by putting the emitter and detector on a quartz surface in which SAW velocities in the given direction are known. As a calibrator we used the $X - Y$ surface of an artificial quartz with the value of $V_R = 3159\,\mathrm{m/s}$ in the Y direction (0°).

IV. EXPERIMENTAL RESULTS

The plots of the wedge edge displacement on the tested surface versus given electric peak position displacement are presented in the Fig. 5.

A striking feature in the Fig. 5 is a very low scattering of the experimental points. The absolute values of V_R for some materials, calculated from the above data, are specifield below.

PMM (plexi) $V_R = 1160\,\mathrm{m/s}$

Bone (along) $V_R = 1611\,\mathrm{m/s}$

Bone (across) $V_R = 1458\,\mathrm{m/s}$

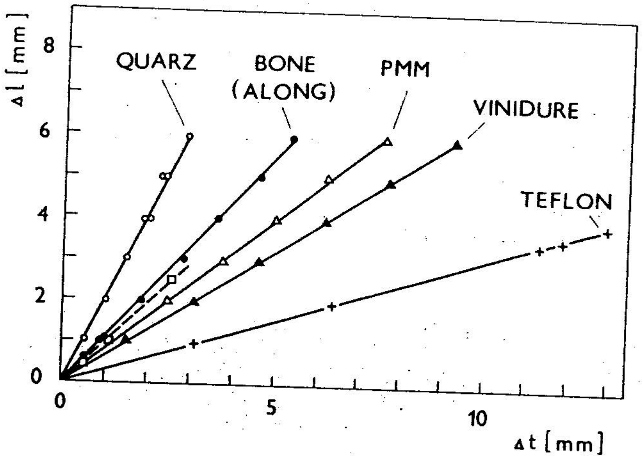

Fig. 5. The plots of the transformer displacements versus electrical peak positions displacements for some materials.

Textolyte $V_R = 1264\,\mathrm{m/s}$

Teflon $V_R = 464\,\mathrm{m/s}$

Vinidure $V_R = 970\,\mathrm{m/s}$

The V_R value for teflon cannot be compared with the data in literature because of their absence. This fact is easy understable and is due to the previously mentioned difficulties.

The random errors of the obtained V_R values were not greater than 0.2%.

V. CONCLUSION

In order to avoid the errors due to contributions from other kinds of waves (other than RW) in the detection signal it is necessary to apply specimens of thickness greater than $20\Lambda_R$. In materials of fiber structure, like wood, the identification of the wave sort is very difficult or sometimes even impossible and because of this experimental fact the V_R data for woods are not presented. In the described method it was possible to evaluate also the damping of RW, but with a low accuracy due to undefinite conditions of contacts. The evaluated value of RW damping for teflon is about 1000 dB/m. Concluding we may say that the elaborated method enables us to widen the scope (range) of acoustical testing methods application in some kind of acoustically "difficult" materials. This work was supported by the Govermment Project CPBP 01 08, D 1.4.

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ГЕНЕРАЦИЯ ПАВ И ИХ СВОЙСТВА В МАТЕРИЯЛАХ ОБЛАДАЮЩИХ НИЗКОЙ АКУСТИЧЕСКОЙ ИМПЕДАНЦИЕЙ И ВЫСОКИМ КОЭФИЦИЕНТОМ ЗАТУХАНИЯ

В этой работе описан принцип действия трансформатора волн Ламбда в ПАВ. ПАВ типа Релея генерованы с помощю этого трансформатора в некоторых акустически трудных материялах были исследованы. Скорость их распространения была измерена с высокой точностю.