Electronic Solution to the QTUD Method for Materials Testing

Zoran Ebersold, Nebojša Mitrović, and Slobodan Đukić

***Abstract*—The method for defectoscopy of materials that uses separated ultrasonic heads for emitting and reception of signals i.e. ultrasonic transmission defectoscopy has not been much in use in science and engineering until now. This method consists of an ultrasonic head for emitting signal and only a single ultrasonic head for its reception. The method described in this paper is named quadraphonic transmission ultrasound defectoscopy (QTUD). It is an ultrasonic defectoscopy method for materials testing that uses a single ultrasonic head for emitting and four ultrasonic heads for receiving of ultrasonic signal. The advantage of this method is its suitability even with porous materials, all based on relatively low frequencies (about few tens of kHz). Therefore, electronic components are cheaper, so the wide application of this method, both in science and industry is possible.**

***Index Terms*—Defectoscopy, quadraphonic transmission method, ultrasonic transmission defectoscopy.**

I. INTRODUCTION

SOUND waves represent propagation of oscillations and can be spread out in solid, liquid and gaseous state [1]. Sound waves are also called ultrasonic waves or ultrasound if their frequency is higher than 20 kHz [2]. This frequency is often cited as the upper limit of the sensitivity range for human hearing. Defectoscopy is a scientific discipline concerned with finding errors i.e. defects in materials. When the ultrasound is used for testing, this method is named as ultrasonic defectoscopy. Samples that are undergoing ultrasound testing do not receive any damage, and therefore this method is listed as a non-destructive material testing method. This method can easily be integrated into technological process of production or as a final stage for control for semi-finished or finished products. Ultrasound defectoscopy is applied primarily in optical opaque materials, materials that strongly absorbs X-rays and in metals where application of electromagnetic signals is not possible due to the “skin effect” [3].

Various methods for the purpose of ultrasound defectoscopy of solid objects have been already developed [4, 5]. Properties of these methods depend on the application and objectives of the measurement. Propagation time and the intensity of ultrasonic waves are the parameters obtained by ultrasonic defectoscopy. These parameters can be applied in various mathematical algorithms [6, 7] for analyzing the condition of a given sample. Usually, applied technique of ultrasound defectoscopy is based on the same ultrasound head for emitting and reception, where the method uses the impulse echo technique. This is common method in the literature and in industry. The impulse echo method currently represents the main "trend" within the ultrasound defectoscopy [8]. However, the application of this method is under high frequencies (several GHz). This causes a huge absorption of ultrasonic waves in samples. Therefore, application of ultrasonic impulse echo method is not possible on very porous materials.

The procedure discussed in this paper has been neglected and developed as a method for using separate heads for ultrasonic emission and reception. The literature provides data on this method employing one head for emitting ultrasound signal and one single ultrasonic head (i.e. sensor) for receiving. The method with two separate heads is named the "transmission ultrasound method".

The aim of this study is to present a concept and technical solution developed for the improvement of transmitting ultrasonic method of defectoscopy for materials with one ultrasonic head(for emitting an ultrasound) and four heads (for the reception), i.e. quadraphonic transmission ultrasound defectoscopy (QTUD). It aims to provide a contribution to the development of science and technology, improving a transmission of ultrasonic method in an effective method for defectoscopy of materials, especially for porous materials. The main advantage of the QTUD method over previous ultrasound methods based on impulse echo methodology is the application of much lower frequencies (about a few tens of kHz, for example 45 kHz). Therefore, it can be successfully applied even on the extremely porous samples (for example various sintered polymers, sintered metals and various indirectly and directly laser-sintered materials).

The block diagram shown in the Fig. 1 represents an operating principle of the QTUD assembly. The components shown in the scheme are: function generator, an ultrasonic transmitter S1, ultrasonic sensors as receivers P1, P2, P3 and P4, adapters A1, A2, A3 and A4 as signal pre-amplifiers, four-channel analogue to digital (A/D) converters and a computer for digital signal processing with appropriate software. For

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Z. Ebersold is with the University of Applied Sciences, Augsburg, Germany, (e-mail: zoran.ebersold@hs-augsburg.de)

N. Mitrović and S. Đukić are with the University of Kragujevac, Technical Faculty, Čačak, Serbia (e-mail: nmitrov@tfc.kg.ac.rs, sdjukic@tfc.kg.ac.rs).