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REVIEW ON THE DESIGN OF NON-CONTACT ULTRASONIC TRANSDUCERS USED FOR CONTROL OF MATERIALS

Established methods for non-destructive ultrasonic testing of materials include the use of ultrasound transducers. The function of these transducers is to produce directly or indirectly piezoelectric effect to generate and detect ultrasonic signals. The best known is the immersion control technique, when the piece is completely immersed in a water bath. But there are some cases when the piece cannot be immersed in the bath due to its large dimensions such as airplane wing, wind turbine blade, airplane fuselage. Also, the tested specimen can be damaged by direct contact with the ultrasonic transducer, for example electrical scheme, porous materials, sandwich composite materials.

However, in the last ten years in the research laboratories and specialized institutions of the world, the emphasis was placed on non-contact ultrasonic control of materials, that is, through an air gap. Unfortunately, the transmission of ultrasound between the transducer and the tested piece through an air gap is insufficient due to the large acoustic impedance mismatch between air and the ultrasound source and air/solid materials [1]. This means that the ultrasound waves is almost entirely reflected at the interfaces between the transducers and tested part. Many methods have been investigated to overcome the acoustic impedance mismatches. Among the most popular achievements, it is worth mentioning the non-contact electrostatic transducers [2,3,4]. These transducers have a wide frequency bandwidth for investigating a large range of materials by different types of waves, [5,6,7,8]. In 1997, Hayward and Farlow [9] designed non-contact piezo-ceramic transducers with 1 till 3 matching layers using a composite design. Transducers of this type have a narrow bandwidth so that the response pulse has a long-time duration. Also, in [10] is specificated that the use of multiple matching layers is intended to increase bandwidth frequencies. Later, were proposed ultrasound transducers with more active layers necessary for frequency bandwidth expansion and simultaneous two-mode excitation (for therapy and imaging), [11,12]. The mismatch between the acoustic impedances of air and piezoelectric ceramics is very large which causes the low sensitivity and narrow bandwidth. The approximation of the impedance values between air and piezo ceramics ensures increased sensitivity and broadening bandwidth, therefore the use of matching layers is a good option in non-contact ultrasound defectoscopy. The main problem in the design and manufacture of non-contact ultrasound transducers consist to choose matching layers with very low acoustic impedances (0,01-0,1 MRayl) and with very low attenuation coefficient (<500 Np/m), [13]. A category of this type of material would be ferroelectrics which are dielectric materials with permanent electrical polarization and good piezoelectric properties, with mechanical flexibility and low acoustic impedance (<0,1 MRayl) [14-15]. This type of transducers is new generation and have the following disadvantage: high design and manufacturing cost, use in metrological environments (constant air temperature and humidity, the presence of impurities in the air cause wrong interpretations signals and frequent failure of transducers).

Non-contact industrial ultrasonic defectoscopy need transducers with low design-production costs, possible to use them in the production sections of construction industries. Such transducers usually have an active element and a passive matching layer (or layers).

Finally, it may be concluded that during the design of non-contact transducers, the following factors must be considered:

a - large mismatch between the acoustic impedances of air and solids,

b - the enormous difference between the propagation speeds of ultrasound in air and solids;

c - high attenuation of ultrasound in air;

d - high frequencies ensure a high spatial resolution but an increased attenuation.

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