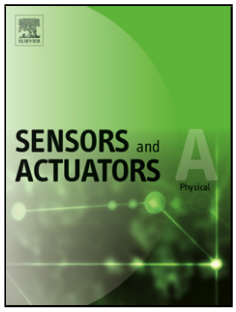

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A modified design of the omnidirectional EMAT for antisymmetric Lamb wave generation

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Highlights

- We propose a modified design of the omnidirectional electromagnetic acoustic transducer (EMAT) for antisymmetric (A0) Lamb wave generation.
- Numerical simulation based on FEM is performed to characterize the magnetic configurations and determine the coil parameter of the EMAT.
- The double-turn coil is used instead of a single spiral coil.
- The proposed EMAT can generate and receive pure single A0 mode Lamb wave signal with high signal to ratio.

Abstract—This work presents a modified design of electromagnetic acoustic transducer (EMAT) that generates only antisymmetric (A0) omnidirectional Lamb wave. The new magnetic configuration includes a solid cylindrical magnet and a ring-shaped magnet surrounding the outside of the solid cylindrical magnet. The diameter of the solid cylindrical magnet is slightly small than the inner diameter of the ring-shaped magnet. The double-turn coil is used instead of a single spiral coil. Numerical simulation is applied to characterize the magnets and determine the coil parameters. Experimental results on a 3mm-thick aluminum plate show that the modified EMAT we proposed can generate and receive pure single A0 mode Lamb wave with high signal to noise ratio and can effectively meet the imaging requirements.

***keywords*—Electromagnetic acoustic transducer, Antisymmetric mode, Lamb wave, Omni-direction**

1. Introduction

Ultrasonic inspection technology has been widely used in nondestructive testing and evaluation (NDT & E) [1]. As is well known, Lamb waves are becoming more and more important in their application and research fields. Compared to ultrasonic body waves, Lamb waves are less attenuated and can travel longer distance. In addition, Lamb wave have multiple modes, and different modes of Lamb waves are sensitive to different types and sizes of defects [2-4]. According to different detection conditions and requirements, the appropriate Lamb wave mode can be selectively generated by mode control means, so we can fully take advantage of each mode of Lamb wave. Electromagnetic acoustic transducers (EMATs) are a type of non-contact ultrasonic transducer [5,6]. EMATs can directly generate and receive Lamb waves on an aluminum plate by means of electromagnetic coupling without coupling medium. With proper structure and parameter design, EMAT can flexibly generate various ultrasonic waves and can work in special environments such as high temperature, high speed and isolation layer [7,8]. In recent years, EMAT Lamb wave tomography technology has attracted widespread attention [9-11]. In order to get high resolution tomography, it is necessary to use an omnidirectional mode-controlled Lamb wave EMAT, and one of the key problems is to generate a single mode Lamb wave.

Single symmetric (S0) mode Lamb wave generation has been demonstrated [12-14] and the relative merits of the S0 and antisymmetric (A0) mode were discussed [4]. It is found that the sensitivity of the A0 mode to thickness variations was shown to be superior to S0 mode, however, when there is liquid loaded, the attenuation of A0 mode is much higher than that of S0 mode [4]. In this paper, we mainly focus on the generation of pure A0 mode Lamb wave. Huang et al. used an EMAT composed of a coil with a contra-flexure structure and a cylindrical permanent magnet to excite and receive the omnidirectional A0 mode in the aluminum plate, and used the EMAT arrays and the tomography technology to achieve detection of corrosion defects in aluminum plates [9]. Nagy et al. used spiral coils and cylindrical magnets that the diameter are much smaller than the coils to excite omnidirectional A0 mode in a thin plate using a magnetostrictive patch based on the Poisson effect by controlling the inclination angle of a Lorentz force [15]. In this work, we propose a modified design of the omni-directional EMAT for generating a single A0 Lamb wave, which facilitates the extraction of travel time due to the elimination of multi-mode phenomena. The experiments are carried out to verify the feasibility of the new EMAT configuration for generating a single A0 mode.

2. Configuration of the EMAT

In this section, the proposed configurations of the A0 mode Lamb wave EMATs will be described in detail. All configurations of Fig. 1(a) ~(c) are composed of a permanent magnet and a spiral coil. According to the generation principle of electromagnetic acoustic transducer, when an alternating current is applied to the coil, the induced eddy currents are generated in the skin layer of the conductive material. The static magnetic field generated by the permanent magnet and the induced eddy current generate the Lorentz force in the material. Then the ultrasonic waves are generated on the surface of the material and propagated to the interior.

2.1 EMAT design