1. INTRODUCTION

The applications of adhesive joints in plates and pipes to increase life, improve stiffness, and protect against corrosion and electrical insulation have resulted in the widespread use of viscoelastic polymer material like epoxy with plates and pipes as adhesive and coating. An example of these joints' application is a three-layer adhesive joint, including an aluminum patch bonded to a surface, such as aircraft aluminum skin, by a viscoelastic epoxy adhesive layer. Repair patches are used to extend the life of the aircraft. Ultrasonic guided waves are used to inspect these adhesive joints. Lamb waves have applications in non-destructive inspection of elastic-viscoelastic multi-layer joints and plates. Some modes of these waves have frequencies with minimum attenuation and are recognizable in inspection by a transducer, and they can also detect the defects in the structures. Low-attenuation lamb waves can be produced in multi-layer structures using angle beam transducers for inspection purposes.

Guided waves propagation in multi-layer structures has been investigated using various methods. The transfer matrix method is applied to model guided waves in multilayered anisotropic and damping media, the use of this method in high frequencies is accompanied with numerical instability. Delta operator technique is applied to improve the stability of transfer matrix method in multilayered anisotropic damping plates. The matrix methods have been presented for modeling the propagation of ultrasonic waves in multilayered media. Both global the matrix method and transfer matrix method are used in these studies. These techniques can be used to obtain attenuation and phase velocity dispersion curves in viscoelastic materials. The propagation of guided waves in multilayered adhesive structures has been investigated using analytical, experimental, and transient FEM simulation methods by taking into consideration the low stiffness and viscoelastic behavior of adhesive layer.

The propagation of lamb and shear horizontal (SH) waves in elastic plates coated with viscoelastic materials has been investigated by Superposition Partial Bulk Waves (SPBW) method. Material damping causes an excessive reduction of an applied signal in an ultrasonic test. The propagation of guided waves in elastic hollow cylinders with viscoelastic coating has been investigated using experimental and analytical methods. Wave equation in elastic hollow cylinders was solved using theoretical boundary value problem and the best modes were specified. The global matrix method has been used to obtain the roots of the characteristic equation. Wave propagation in linear viscoelastic laminates has been investigated using spectral finite element method or semi-analytical finite element method (SAFE), the damping loss factor was estimated for waves in low frequencies, and the stiffness matrix was assumed to be real. The damping loss factor has been obtained using the SAFE method and taking into consideration the complex stiffness matrix. To model ultrasonic wave propagation in different waveguides, the SAFE method is used.

The titanium repair patches bonded to the aircraft aluminum skin have been inspected using ultrasonic guided waves, wave structures were plotted using a theoretical method and selected the mode shape with maximum in-plane displacement for inspection, although the effect of material damping did not take into consideration.

In the present study, the propagation of lamb waves in...