

*Review*

# A Review of Recent Advances in Unidirectional Ultrasonic Guided Wave Techniques for Nondestructive Testing and Evaluation

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**Abstract:** Unidirectional ultrasonic guided waves (UGWs) play a crucial role in the nondestructive testing and evaluation (NDT&E) domains, offering unique advantages in detecting material defects, evaluating structural integrity, and improving the accuracy of thickness measurements. This review paper thoroughly studies the state of the art of unidirectional UGWs before presenting a comprehensive review of the foundational mathematical principles of unidirectional UGWs, focusing on the recent advancements in their methodologies and applications. This review introduces ultrasonic guided waves and their modes before looking at mode excitability and selectivity, signal excitation, and mechanisms used to generate and receive guided waves unidirectionally. This paper outlines the applications of unidirectional UGWs to reflect their effectiveness, for instance, in measuring thickness and in identifying defects such as cracks and corrosion in pipelines, etc. The paper also studies the challenges associated with unidirectional UGW generation and utilisation, such as multi-mode and side lobes. It includes a review of the literature to mitigate these challenges. Finally, this paper highlights promising future perspectives and develops directions for the technique. This review aims to create a useful resource for researchers and practitioners to comprehend unidirectional ultrasonic guided waves' capabilities, challenges, and prospects in NDT&E applications.

**Keywords:** ultrasonic guided waves (UGWs); unidirectional UGWs; nondestructive testing and evaluation (NDT&E)



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## 1. Introduction

Ultrasonic guided waves (UGWs) are mechanical waves propagating along structures, such as pipes, plates, and rods, and are bound by the surfaces or boundaries along which they propagate. Their ability to travel long distances while maintaining sensitivity to defects makes them highly valuable for applications like nondestructive testing and evaluation (NDT&E), structural health monitoring (SHM), and industrial inspection. Guided waves offer advantages over bulk waves because they can propagate through complex geometries and reach areas that would otherwise be inaccessible [1–3]. UGWs propagate as distinct modes with dispersion relationships that depend on the material properties and waveguide geometry of the sample [4–9].

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