An Analytical Inverse Method for Determination of Thick Plate Dilatational Wavespeed

Mr. Greg Gartland
Michigan State University
East Lansing, MI
gartlan3@egr.msu.edu

Dr. Andrew Hull
Naval Undersea Warfare Center
Newport, RI
HullAJ@npt.nuwc.navy.mil

Dr. Clark Radcliffe
Michigan State University
East Lansing, MI
radcliffe@egr.msu.edu

Introduction

Acoustical response of a material, specifically the insertion loss and echo reduction, is vital for any acoustical design. Closed-form solutions have recently been developed that predict the acoustic insertion loss and echo reduction of a thick plate provided the correct material properties are supplied. One of the essential properties in understanding and predicting the acoustical response of a system is the dilatational wavespeed.

The inverse method developed utilizes a Newton-Raphson iteration on the known closed-form solutions to obtain the dilatational wavespeed of a material from echo reduction test data. The analytical method is demonstrated with acoustical test data obtained from the United States Naval Undersea Warfare Center (NUWC).

Experimental Test Setup

Echo reduction test data was obtained from materials at the NUWC Underwater Acoustic Test Facility (ATF) represented in Fig. 1. The ATF acquires the incident and reflected acoustical data and produces an echo reduction measurement as a magnitude and phase angle.

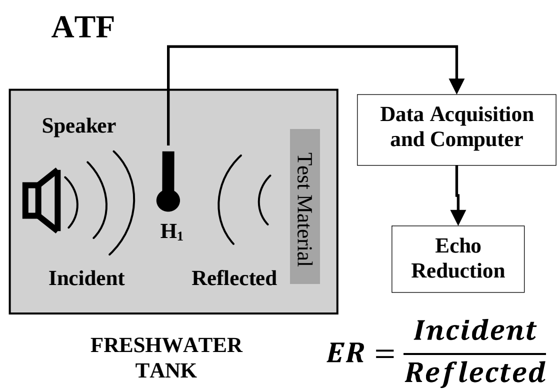

Figure 1. Acoustic test facility diagram

System Model

The plate is modeled as an infinite, thick plate loaded on each side with fluid [1]. The fluid provides continuous excitation pressure on the plate at a prescribed incidence angle. If the angle is restricted to zero only the dilatational wavespeed is required to predict the acoustical response. The reduced equations are utilized in the inverse method to acquire the dilatational wavespeed from test data.

Inverse Method

The inverse method relies on a Newton-Raphson iteration to back out the dilatational wavespeed from raw test data. An initial wavespeed is supplied, evaluated with the known equations, and the results compared to the test data. If the difference is zero, the wavespeed was correct, if not, it is adjusted and reinserted into the equations as seen in Fig. 2.

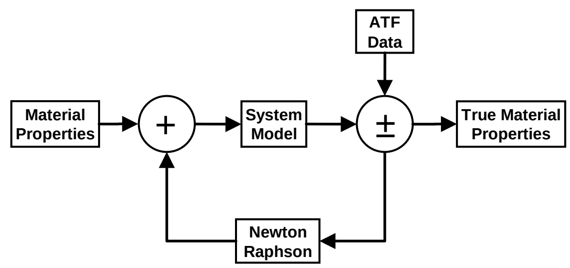

Figure 2. Inverse method diagram

Physical Testing

Echo reduction test data was obtained for two different urethane materials from the ATF. The previous inverse method was then employed on the data and the dilatational wavespeeds were ascertained. The acquired results were verified at specific frequencies using a wavelength method as seen in Fig. 3.

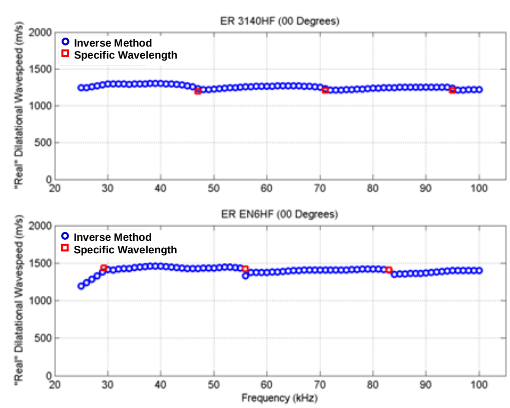

Figure 3. Acquired dilatational wavespeeds

References

[1] A.J. Hull, "Analysis of a Fluid-Loaded Thick Plate", *Journal of Sound and Vibration*, Vol. 279, January 2005, pp. 497-507.