Accepted Manuscript

Nonlinear effects of micro-cracks on long-wavelength symmetric Lamb waves

Marek Rjelka, Bernd Köhler, Andreas Mayer

PII:	S0041-624X(18)30145-8
DOI:	https://doi.org/10.1016/j.ultras.2018.06.001
Reference:	ULTRAS 5759

To appear in: Ultrasonics

Received Date:1 March 2018Revised Date:25 May 2018Accepted Date:2 June 2018



Please cite this article as: M. Rjelka, B. Köhler, A. Mayer, Nonlinear effects of micro-cracks on long-wavelength symmetric Lamb waves, *Ultrasonics* (2018), doi: https://doi.org/10.1016/j.ultras.2018.06.001

This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

ACCEPTED MANUSCRIPT

Nonlinear effects of micro-cracks on long-wavelength symmetric Lamb waves

Marek Rjelka^{a,*}, Bernd Köhler^a, Andreas Mayer^b

^a Fraunhofer IKTS, Maria-Reiche-Straße 2, D-01109 Dresden, Germany ^b HS Offenburg, University of Applied Sciences, D-77723 Gengenbach, Germany

Abstract

For an elastic medium containing a homogeneous distribution of micro-cracks, an effective one-dimensional stress-strain relation has been determined with finite element simulations. In addition to flat micro-cracks, voids were considered that contain a Hertzian contact, which represents an example for micro-cracks with internal structure. The orientation of both types of micro-cracks was fully aligned or, for flat micro-cracks, totally random. For micro-cracks with Hertzian contacts, the case of random orientation was treated in an approximate way. The two types of defects were found to give rise to different degrees of nonanalytic behavior of the effective stress-strain relation, which governs the nonlinear propagation of symmetric (S0) Lamb waves in the long-wavelength limit. The presence of flat micro-cracks causes even harmonics to grow linearly with propagation distance with amplitudes proportional to the amplitude of the fundamental wave, and gives rise to a static strain. The presence of the second type of defects leads to a linear growth of all harmonics with amplitudes proportional to the square of the fundamental amplitude, and to a strain-dependent velocity shift. Simple expressions are given for the growth rates of higher harmonics of S0 Lamb waves in terms of the parameters occurring in the effective stress-strain relation. They have partly been determined quantitatively with the help of the FEM results for different micro-crack concentrations.

Keywords: micro-cracks, effective material properties, FEM, penny-shaped cracks, Hertzian contact, nonlinear ultrasound, harmonic generation, perturbation theory, non- destructive evaluation, Lamb waves

1. Introduction

Nonlinear phenomena of acoustic waves can be efficiently applied to the detection of pre-fatigue in an early stage. In this context, guided waves, especially Rayleigh and Lamb waves, have moved more and more into the focus [1]. In

Preprint submitted to Ultrasonics

^{*}Corresponding author

Email address: marek.rjelka@ikts.fraunhofer.de (Marek Rjelka)

Download English Version:

https://daneshyari.com/en/article/8129829

Download Persian Version:

https://daneshyari.com/article/8129829

Daneshyari.com