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Optical Interferometry Methods Used to Study Interaction of Acoustical Waves with Structural Inhomogenities

Jan Trnka, Pavla Dvořáková

Institute of Thermomechanics AS CR, v.v.i. CZECH REPUBLIC

Abstract

Poster is concerned with the scattering of Lamb waves mode A_0 in the surrouding of structural inhomogenities in thin plates. The transient state is caused by different way of generating of ultrashort impact loading. The responses are detected by both full-field and pointwise optical methods. We show results of Double-Pulse Holointerferometry, Electonic Speckle Patterns Interferometry and Laservibrometry.

Introduction

Increasing number of terrorist attacks gave rise to antiterrorist activities. They include, among others things, searching dangerous added mass (plastic bombs) or artificial structural inhomogenities. The searching techniques to detect the structural inhomogenities have to be non-destructive, simple, reliable and portable.

Powerful and promising techniques are based on analysis of scattered guided flexural waves which are artificialy generated in the structure under investigation.

When the guided waves interfere with inhomogenities, a scattered displacement field is detected.

It is essential to first know responses of perfect structure to compare them with suspecious responses.

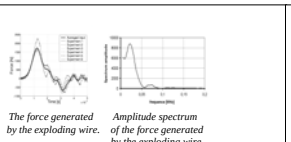
Experiments

A successful research of stress wave propagation in solids is conditioned by the optimal impact generation. The impact has to be precise and repeatable. The history of an impact loading has to be of short duration in time and concentrated in space.

The history of the generated impact force is measured by means of miniature strain gauges glued to a slender Davies' bar [1].

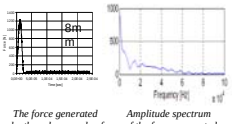
The amplitude of the impact force generated by loading element varies, depending on the shape of element, approximately in the range of 600 - 2700N [2]. Duration of the generated force varied in the range 10 - 30μs, see Fig.1. History of the force generated by two spheres made of steel are shown in Fig.2. Duration of the generated force depends on the diameter of the sphere.

The amplitude of the impact force generated by focused ruby laser beam [3] varies, depending on the quality of surface, approximately in the range of 6-200N. Duration of the generated force is approx. 10 μs, see Fig.3.



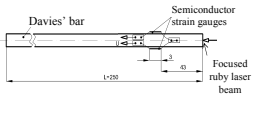
The force generated by the exploding wire. *Amplitude spectrum of the force generated by the explodinq wire.*

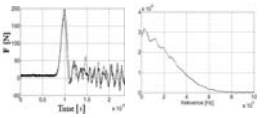
Fig. 1



The force generated by the sphere made of steel. *Amplitude spectrum of the force generated by the sphere.*

Fig. 2





The force generated by focused ruby laser beam and its amplitude spectrum

Fig. 3

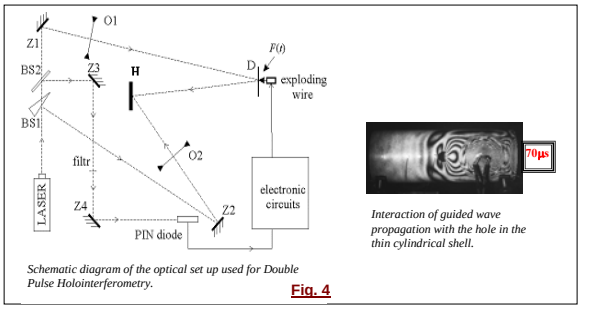
The great advantage of guided waves arises in propagating over long distance in thin walled plates and shells while allowing the fast and efficient detection of inhomogenities in large structures.

There exists a lot of nondestructive methods based on analysis of these types of waves, some are applicable only in laboratory conditions, e.g. holinterferometry or ESPI, others are also applicable *off-lab*. The first class of methods give mostly full-field so called "frozen state" of wave motion, while the latter class yields point-wise history of motion on surface under investigation.

We focused on both types of these methods and we show our results. Our success in application of some methods consists is in making use of the frequency analysis instead of the time domain analysis of the recorded waveforms.

Results

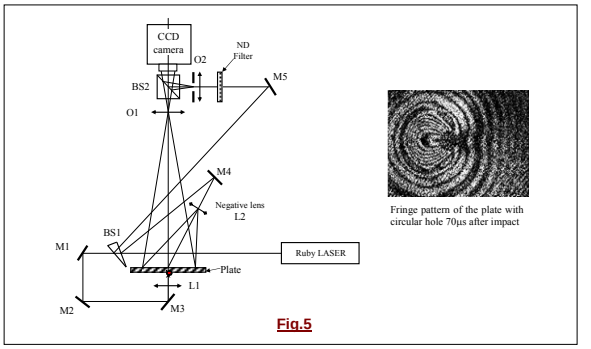
To analyse the effect of the inhomogenities, we made use of the data obtained by both holography (Fig.4) or ESPI [4] (Fig.5) and point-wise measurement by the laservibrometer (Fig.6) or accelerometer (Fig.7). The former methods provide us full-field only qualitative information while the latter one yields the quantitative data in the time domain. Using FFT enables us to get data in the frequency domain.



Schematic diagram of the optical set up used for Double Pulse Holointerferometry.

Interaction of guided wave propagation with the hole in the thin cylindrical shell.

Fig. 4



Fringe pattern of the plate with circular hole 70μs after impact

Fig.5

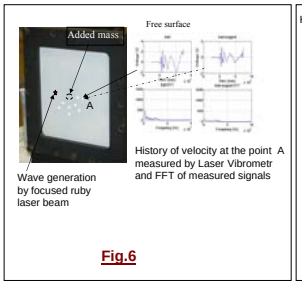


Fig.6

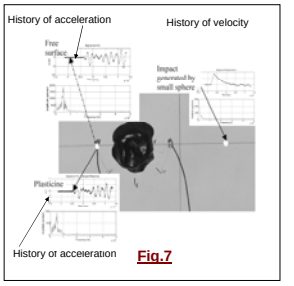


Fig.7

Conclusions

This poster is concerned with experimental methods promising for analysis of interaction of the guided wave with masses added on the surface of the thin plates. The waves are generated by different ways. History of the force is measured by the Davies' bar. Application of the interferometric methods shows the effect of added mass on both the interferomeric patterns of full- field methods and the changes in frequency spectrum of point-wise measured velocity or acceleration.

Combining the whole-field methods along with the point-wise history measurement of acceleration and velocity, give us a new look on searching "suspecious" mass which is added and fixed to thin walled structures.

Acknowledgements

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