Simulation of Laser-excited Surface Acoustic Waves Travelling on a Steel Hemisphere Shell

J. Mäkinen[1], D. Veira Canle[1], R. Blomqvist[1], A. Salmi[1], E. Hæggström[1]

[1]Department of Physics, Division of Materials Physics, University of Helsinki, Helsinki, Finland

Abstract

Non-contacting guided wave tomography based on laser ultrasonic waves can be used to inspect structures that are inaccessible to traditional ultrasound methods. Such structures could be, chemically or physically hard to reach, e.g. hot metal structures, metal implants inside tissue or metals in chemically corroding environments. The shape of these kinds of structures is sometimes simple, which makes the propagation path of the guided waves well defined. A spherical structure, however, requires that one accounts for multiple propagation paths and echoes of the guided waves. We set up a 3D multiphysics model in COMSOL Multiphysics® to verify our measurement results of guided wave propagation on a steel hemisphere featuring a defect.

The time dependent multiphysics model uses the Heat Transfer module to model the laser excitation as a heat source on the steel hemisphere shell. There are two mechanisms for the guided wave generation from the laser excitation, thermal expansion and ablation. Only the thermal expansion was considered since the contribution from ablation is negligible at low excitation energies. The Heat Transfer module was coupled to the Structural Mechanics module to model the generation of the guided waves with the Thermal Expansion multiphysics coupling.

The predicted displacements on the outer rim of the steel hemisphere shell are compared to experimental results obtained with an Nd:YAG laser excitation with a laser doppler vibrometer pickup. From the displacement data a circular, 9.5mm diameter, defect can be detected in both settings. The predicted frequencies of the simulated guided waves are also compared to the experimental ones.

Figures used in the abstract

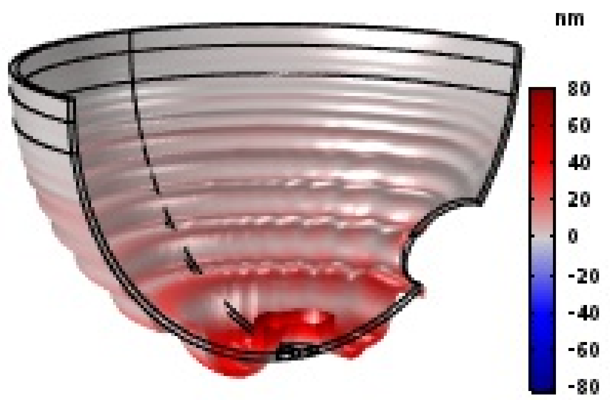

Figure 1: Guided waves propagating on a steel hemisphere shell determine the position and size of a defect.