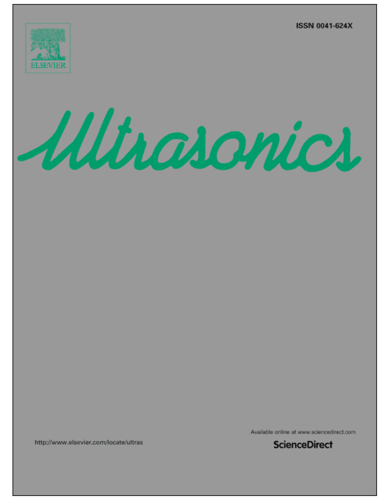

Resonance analysis of a high temperature piezoelectric disc for sensitivity characterization

Prathamesh N. Bilgunde, Leonard J. Bond

PII: S0041-624X(17)30902-2
DOI: https://doi.org/10.1016/j.ultras.2018.02.007
Reference: ULTRAS 5700

To appear in: *Ultrasonics*

Received Date: 29 October 2017
Revised Date: 5 February 2018
Accepted Date: 7 February 2018

Resonance analysis of a high temperature piezoelectric disc for sensitivity characterization

Prathamesh N. Bilgunde[1] and Leonard J. Bond[1, 2,a)]
[1]Department of Aerospace Engineering, Iowa State University
[2]Center for NDE, Iowa State University,1915 Scholl Road, Ames, IA-50011
[a)] Corresponding author: bondlj@iastate.edu

Abstract:

Ultrasonic transducers for high temperature (200°C+) applications are a key enabling technology for advanced nuclear power systems and in a range of chemical and petro-chemical industries. Design, fabrication and optimization of such transducers using piezoelectric materials remains a challenge. In this work, experimental data-based analysis is performed to investigate the fundamental causal factors for the resonance characteristics of a piezoelectric disc at elevated temperatures. The effect of all ten temperature-dependent piezoelectric constants (ε_{33}, ε_{11}, d_{33}, d_{31}, d_{15}, s_{11}, s_{12}, s_{13}, s_{33}, s_{44}) is studied numerically on both the radial and thickness mode resonances of a piezoelectric disc. A sensitivity index is defined to quantify the effect of each of the temperature-dependent coefficients on the resonance modes of the modified lead zirconium titanate disc. The temperature dependence of s_{33} showed highest sensitivity towards the thickness resonance mode followed by ε_{33}, s_{11}, s_{13}, s_{12}, d_{31},d_{33}, s_{44}, ε_{11}, and d_{15} in the decreasing order of the sensitivity index. For radial resonance modes, the temperature dependence of ε_{33} showed highest sensitivity index followed by s_{11}, s_{12} and d_{31} coefficient. This numerical study demonstrates that the magnitude of d_{33} is not the sole factor that affects the resonance characteristics of the piezoelectric disc at high temperatures. It appears that there exists a complex interplay between various temperature dependent piezoelectric coefficients that causes reduction in the thickness mode resonance frequencies which is found to be agreement in with the experimental data at an elevated temperature.

Keywords: piezoelectric; transducer; ultrasonics; high temperature; finite element

1. Introduction

Generation IV fast nuclear reactor designs are being developed to support sustainable development, economic competitiveness, and improved safety [1]. Providing in-service inspection and repair (ISI&R) is a key enabling technology and presents major technical challenges which must be addressed to ensure safety of liquid sodium cooled fast reactors [2].