Numerical Analysis of High Performance Piezoelectric Transducers for Ultrasonic Cutting

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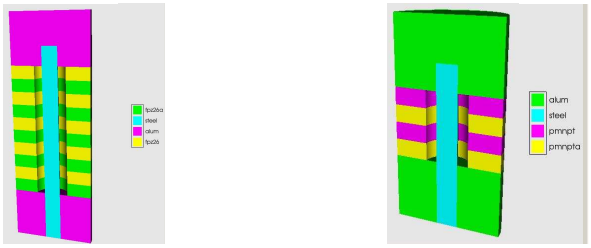
Introduction:

The new single crystals such as PMN-PT possess excellent piezoelectric properties than the conventional PZT series ceramic materials. This makes these materials attractive for a range of ultrasonic applications. However, it is believed that pressure and temperature conditions in various ultrasonic applications affect the performance of the piezoelectric material and thus the transducer. Therefore, numerical analysis could play an important role in predicting the behaviour of an ultrasonic transducer under these conditions. This research aims to conduct a feasibility study for the inclusion of single crystal piezoelectric materials in high power ultrasonic transducers such that high performance piezoelectric transducers for cutting applications can be developed.

Method:

As an initial phase of the work, two transducer models with stacks of PZT and PMNPT materials have been studied numerically by using PZFlex (Weidlinger *Associates, USA*). This was done in order to study the effect of these materials on the performance of a transducer. In the later stage, the analysis is carried out considering the actual operating conditions which is achieved using the data obtained from material characterization under pressure and temperature conditions [1]. Based on the numerical analysis results, the transducers will be fabricated in order to practically observe the effects of the materials.



(a) **(b)**

Figure 1: 2D Axisymmetric Transducer Models with PZT (a) and PMNPT (b)

Results:

The simulation results suggest that using single crystal materials, the performance of the transducer is increased, while the size of the stack is reduced by 50%. This means that smaller new single crystal transducer can be fabricated to obtain the same or better properties than those achieved by the conventional PZT ceramic based transducer.

Table 1: Comparison of PZT and PMNPT based Transducer Models

Material	PZT	PMNPT
No. of rings	10	5
fe	25.1 kHz	24.9 kHz
fm	32 kHz	38 kHz
k_{eff}	0.62	0.75
Q_M	55.7	7.1

Reference

[1] Z.Qiu, M.R.Sadiq, C.Démoré, M.F.Parker, P.Marin, K.Mayne, and S.Cochran,"Characterisation of Piezocrystals for Practical Configurations with Temperature- and Pressure-Dependent Electrical Impedance Spectroscopy". IEEE Trans. Ultrason. Ferroelec. Freq. Contr., in press.