Improved Ultrasonic Piezoceramic Sandwich Transducer

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ABSTRACT.

This paper presents an improved ultrasonic piezoceramic sandwich transducer, utilised for ultrasonic field in narrow lift stations, wet well, flumes and filter beds. The piezoceramic sandwich transducer powered by a signal generator and it is suitable to generate ultrasound with two piezoceramics and the exponential horn at 35 kHz resonance frequency. From the experiments it can be proved that the ultrasonic piezoceramic transducer acoustical power and vibration amplitude mainly depends on the piezoceramic tores and the ratio between the diameter of the horn ends and material elasticity coefficient. The advantage of the exponential horn is that the beam angle is narrower which is suitable for narrow lift stations measurement. The piezoceramic sandwich transducer and the air-coupled transducer are modeled in order to optimize output with material physical parameter changing. The simulation results show good agreement with experiments and based on the numerically modeling trials, more robust design would become true without extensive cutting or trying prototype. The polar pattern results in lab are prominent.

KEY WORDS: ultrasonic; piezoceramic ring; sandwich transducer; narrow beam angle

INTRODUCTION

Increasing concern for ultrasonic piezoceramic sandwich transducer has, in recent years focused studies of energy transmission. Royster (1969) explained that the ultrasonic piezoceramic sandwich transducer is used near its resonance frequency, which yields the highest acoustic output power and efficiency. The signal power generator supplies the ultrasonic piezoceramic sandwich transducer, which converts the electrical oscillation into mechanical vibration. Wevers (2005), Berlincourt (1964) and Wilson (1985) have designed more. Ultrasonic transducer is applied to various purposes because of these beneficial effects. For example, it can be used to enhance reaction rates, clean glass bath, and form nano-particles of metals and level measurement pharmaceutical products. It is used in the in narrow lift stations, wet well, flumes and filter beds and even on the sea. The energy transmission depends on piezoceramic crystal design and mechanism structure design. The crystallization process is a possible improvement that can be used to power ultrasound, but it is difficult for an observation of all the phenomena occurring during sonocrystallization. Thus, modifying the mechanism structure of ultrasonic transducer is a better option and it can be easily proved.

Chilibon (2002) has analyzed that the acoustical performance of the ultrasonic piezoceramic sandwich transducer is dependent on the piezoelectric, dielectric and number of piezoceramics and the shape of metallic radiator and the ultrasonic piezoceramic sandwich transducer with short pulses should have low mechanical factor for wide bandwidth and a perfect compact impulse response.

In this paper, an ultrasonic piezoceramic sandwich transducer with 2 piezoceramic rings as the transducer driver and the exponential horn made of rubber as matching layer has been designed and manufactured. Both 3-D finite element and experiment analysis have been done to prove the transducer is effective.

PIEZOCERAMIC SANDWICH TRANSDUCER ANALYSIS

BASIC THEORY ANALYSIS

The active element of the device is a sandwich transducer, made of a piezoceramic tore stack with metal cylinders (Figure 1). This electromechanical transducer works on the basis of the inverse piezoelectric effect, converting electrical power into a mechanical displacement in the range of tens of microns. All device elements are fixed and pre-stressed by a stainless steel screw, which induces an initial polarization of the piezoceramic stack. The vibration amplitude of the sandwich radiator depends on PZT tores number, PZT material elasticity coefficients and the metal elasticity coefficients. Maximum peak to peak displacements of the transducer radiating face would be in order of tens microns, when operating at resonance frequency.

Morgan Matroc Limited has designed a simple metal - piezoceramic - metal sandwich transducer to resonate at a given fundamental frequency, in the plate thickness direction which is based on the following equation: