Flexural Transducers for Flow Metering Applications, a First Viability Study

T J R Eriksson, S N Ramadas* and S M Dixon

University of Warwick, United Kingdom
*Elster-Instromet, Belgium
Email: t.j.r.eriksson@warwick.ac.uk

Introduction and Motivation

Ultrasonic technology is widely used in flow metering applications, providing precise measurements, comparatively small disturbance of the flow, and a broad operating range of both pressures and flow velocities. Flexural ultrasonic transducers[1] use the bending modes in a thin plate[2] (Fig. 1), and are routinely used for air-coupled ultrasonics, because of their high efficiency. They can operated at lower excitation voltages than conventional piezoelectric transducers, which makes them advantageous from an intrinsic safety perspective. Flexural transducers are also associated with lower manufacturing costs. By eliminating the matching layers, the number of production steps as well as the number of bond surfaces, that can fail over time, are reduced. These properties suggest that the technology could be applicable to flow metering.

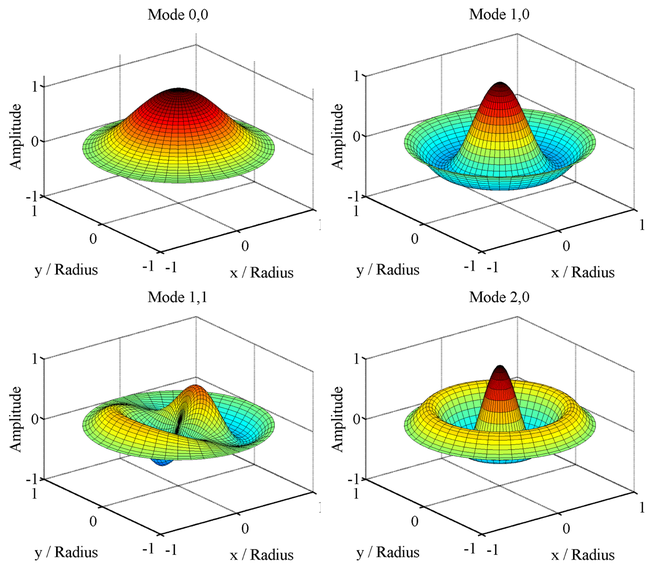

Fig. 1 Analytical mode shapes of an edge clamped plate.

Methods

Robust titanium flexural transducers operating at ~90 kHz, in the second axisymmetric vibration mode, were built (Fig. 2). The transducers were then tested in transmit-receive (TX-RX) mode at static pressures up to 13 bar in air, and at ambient pressure in air with flow velocities up to 12 ms^{-1}.

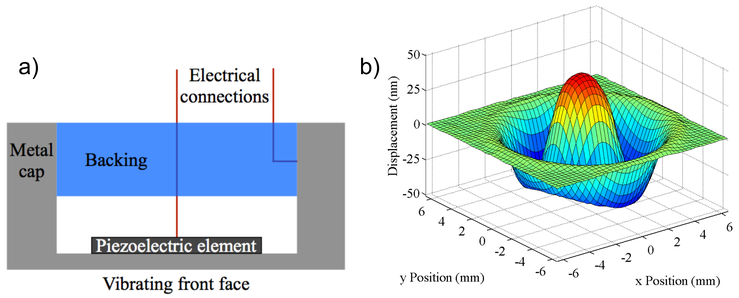

Fig. 2 a) Cross section of a typical flexural transducer, and b) the measured displacement amplitude across the radiating face of a finished transducer.

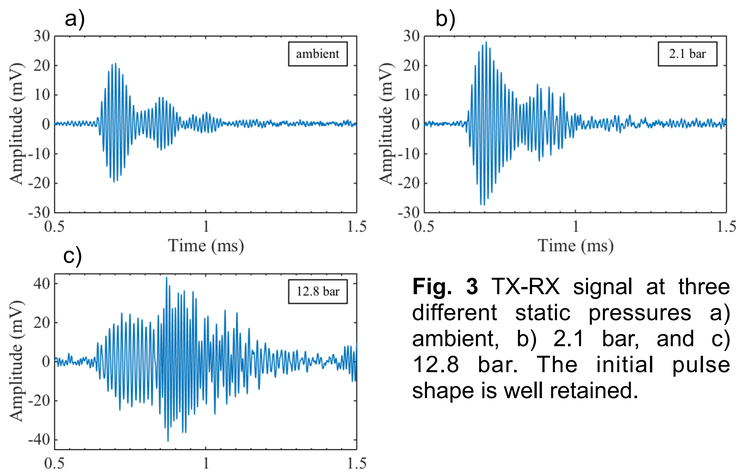

Fig. 3 TX-RX signal at three different static pressures a) ambient, b) 2.1 bar, and c) 12.8 bar. The initial pulse shape is well retained.

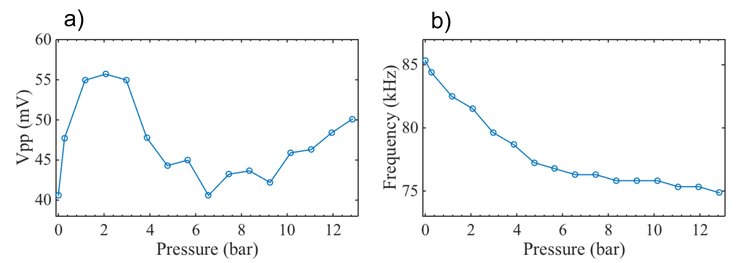

Fig. 4 a) Vpp and b) frequency of the initial pulse plotted against pressure load.

Results

Fig. 3 shows the TX-RX signal at different pressures. Although the signal shape changes, the initial pulse, which in flow metering tends to be used for time of flight (TOF) measurements, is similar. There is also an amplitude change, which is presented in Fig. 4 a). There is an initial increase in amplitude with increasing pressure, followed by a sharp drop, but overall the amplitude remained close to or above the amplitude at ambient pressure. The frequency of the signal is also affected by the pressure load, as shown in Fig. 4 b). The pressure load acts similar to a mass load, causing a decrease in the resonance frequency of the transducers. Fig. 5 shows the TX-RX signal for zero flow and 9 ms^{-1} air flow. The signal shape and amplitude are relatively well conserved.

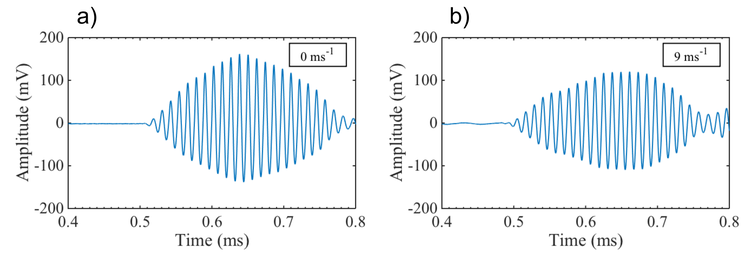

Fig. 5 TX-RX signal at a) 0 flow velocity and b) 9 ms^{-1}

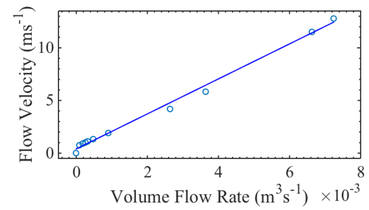

Fig. 6 Flow velocity measured in a residential meter setup, plotted against the volumetric flow rate determined by a diaphragm meter.

Conclusions

The 90 kHz flexural titanium transducers show potential for flow metering applications. Without pressure equalisation the transducers were shown to operate up to 13 bar. The trend in Fig. 3 a) seems to indicate an increasing amplitude with higher pressures. The transducers are also shown to operate well at low flow velocities, up to 12 ms^{-1}, in a residential meter setup. The pulse shape was shown to be well retained, which leads to precise TOF measurements and hence precise velocity readings.

References

[1] C.P. Germano, IEEE Trans. Audio Electroacoust., AU19(1), 6-12, 1971.
[2] A.W. Leissa, *Vibration of Plates*. U.S. Government Press, Washington, 1969.

elster

ULTRASOUND GROUP
DEPARTMENT OF PHYSICS

THE UNIVERSITY OF WARWICK