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Development of Variable Focal Length Ultrasonic Transducer by Changing Curvature of PVDF

Changhun Seok[1†], and Young.H Kim[1*] ([1]Applied Acoustics Lab, Korea Science Academy of KAIST)

1. Introduction

Controlling the focal length of concave ultrasonic transducers has been great concen. HIFU (high intensity focused ulltrasound) transducer with controllable curvature has been investigated [1] This research used piezoceramic array transducer for HIFU and change the curvature by changing the air pressure in the housing of the transducer. However, this arrayed transducer is hard to focus in one single point and difficult to change the curvature, and it is not suitable to accurate measurement such as position detection. Instead of using piezoceramic array, PVDF (polyvinylidene fluoride) was employed as a transducer material since it has flat and flexible structure, changing curvature is very easy to control.

In the present work, computer simulation was carried out to show the relationship of the acoustic fields and change of focal length for the concave curved PVDF transducer. Just chainging the curvature of PVDF transducer enables the focal legnth be variable.

2. Computer Simulation Result

In the present work, MATLAB program was employed in order to calculate acoustic fields and to determine the focal length of PVDF transducer. Curved PVDF transducer was assumed as a set of line source, so that the acoustic intensity is inverse proportional to distance ($I \propto 1/r$).

The curve shape of PVDF transducer was assumed as the three types of functions: arc of circle, arc of ellipsoid and parabola which have common fixed points, middle and two endpoints.

Fig.1 shows calculated acoustic fields generated from PVDF transducer. In this case, middle and two ends points are (0, 0), (0.123 m, 0.05 m) and (-0.123 m, 0.05 m), respectively.

Fig. 1(a), (b) and (c) are acoustic fields for the curve shapes of arc of circle, arc of ellipsoid with eccentricity of 0.3 and parabola, respectively.

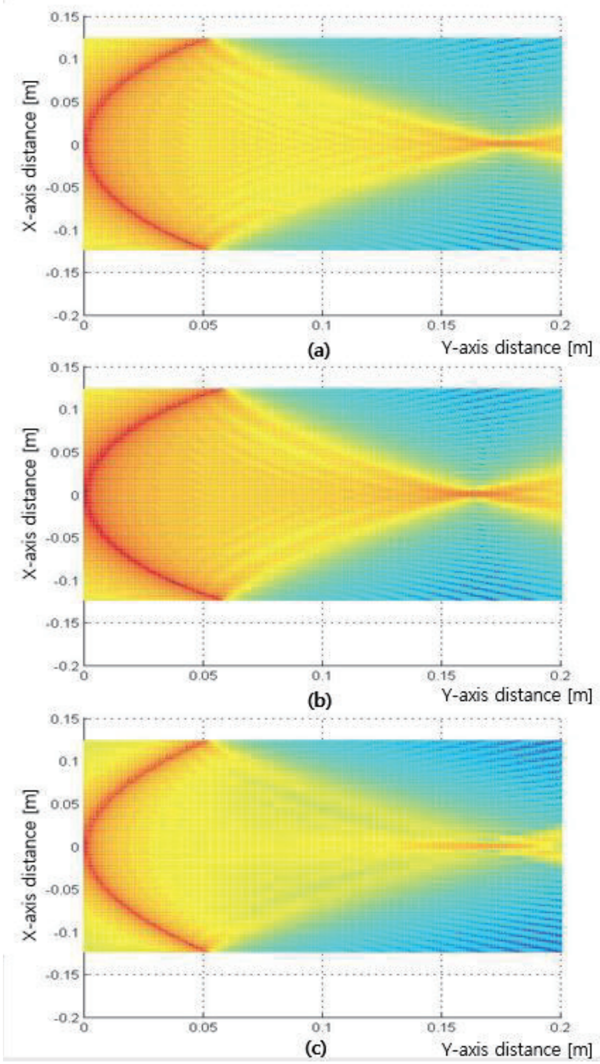

Fig.1 Acoustic fields generated by PVDF transducer at 50 kHz. Intensity is in log scale.

- **(a) Parabola with two endpoints on (0.123 m, 0.05 m) and (-0.123 m, 0.05 m).**
- **(b) Arc of circle with two endpoints on (0.123 m, 0.05 m) and (-0.123 m, 0.05 m).**
- **(c) Ellipsoid function with e=0.3, two endpoints on (0.123 m, 0.05 m) and (-0.123 m, 0.05 m).**

**corresponding author, E-mail: yhkim627@kaist.ac.kr

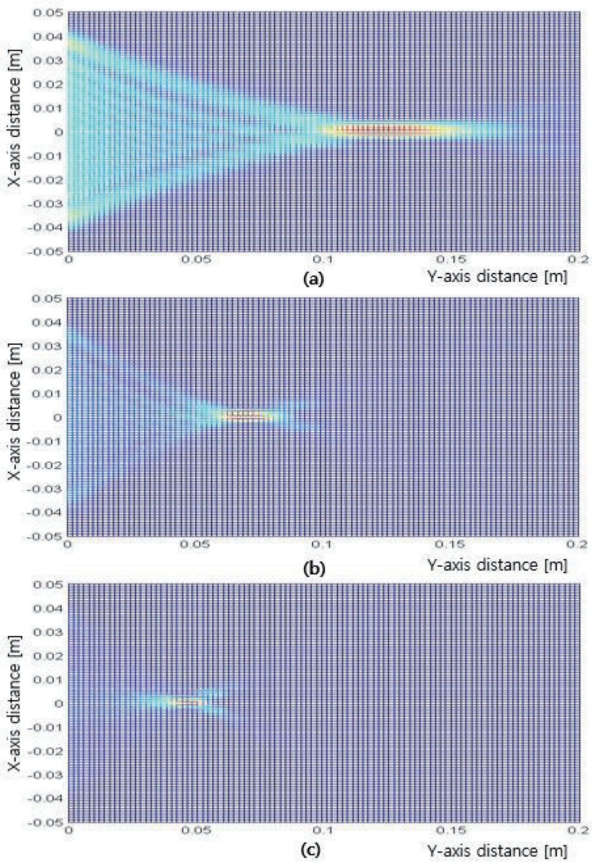

Fig.2 Acoustic fields calculated by computer simulation.

(a) 100kHz frequency on $y=3x^2$ curvature
(b) 100kHz frequency on $y=5x^2$ curvature
(c) 100kHz frequency on $y=7x^2$ curvature

The results show the same focal length of 17cm and similar acoustic fields for all curve shape. It means that the change of curve shape is not critical to the acoustic fields and focal length when middle and two endpoints of PVDF transducer is fixed. It means that the accurate fit of curvature of PVDF transducer is not important and 3 fixed points are enough to determine the focal point.

Curvature and frequency of PVDF transducer were considered to find differences in acoustic fields. Parabola was selected as a curve shape of PVDF transducer. Fig.2 shows acoustic fields by changing the curvature of PVDF transducer. Comparing three graphs, as the curvature increase, the focal length becomes shorter and more concentrated. Fig.3 shows acoustic fields by changing the frequency of PVDF transducer. From these results, Higher frequency make narrower and concentrated focal point compared to the lower frequency.

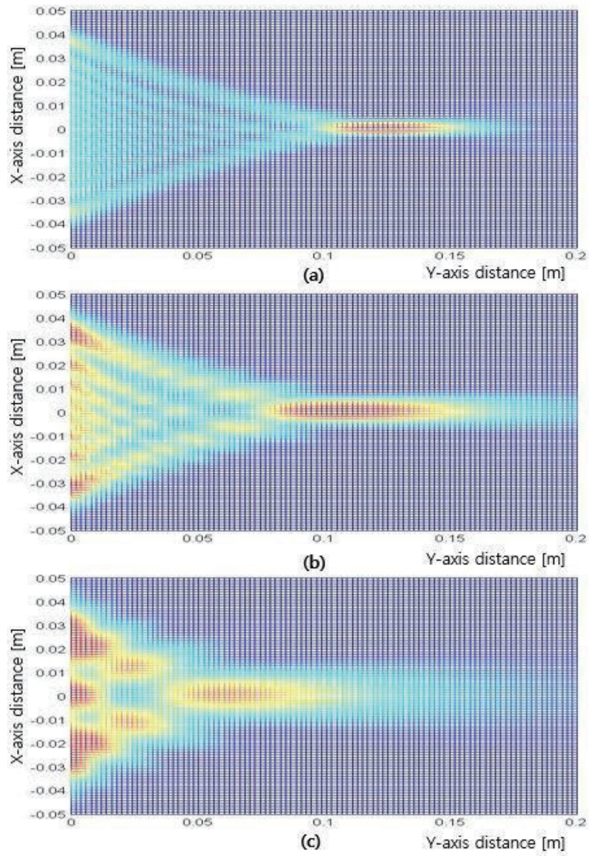

Fig.3 Acoustic fields calculated by computer simulation.

(a) 100kHz frequency on $y=3x^2$ curvature
(b) 50kHz frequency on $y=3x^2$ curvature
(c) 20kHz frequency on $y=3x^2$ curvature

3. Conclusion

In the present work, acoustic fields and focal length in several conditions were determined by using computer simulation. It was found that the change of curve shape is not critical to the acoustic fields and focal length when middle and two endpoints of PVDF transducer is fixed. It means that the accurate fit of curvature of PVDF transducer is not important and 3 fixed points are enough to determine the focal point. It was also found that higher frequency ultrasound make narrower and concentrated focal point. Changing the curvature of PVDF transducer changes the focal length significantly.

Acknowledgment

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References

1. J. Kim, M. Kim and K. Ha, HIFU Transducer with Controllable Curvature, 2013 Joint UFFC, EFTF and PFM Symposium, pp. 1133-1136