Simulation Analysis on Cymbal Transducer

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Keywords: cymbal transducer, bandwidth, free-field voltage sensitivity, finite element

Abstract. The resonance frequency of the cymbal transducer ranges from 2kHz to 40kHz and its effective electromechanical coupling factor is around 20%. Finite element analysis has been performed to ascertain how the transducer's makeup affect the transducer's performance parameters. Two-dimensional axisymmetric model of the cymbal transducer was founded by finite element software-ANSYS, the application of the element type was discussed and the FEM models were built up under the far field condition. Eight groups of cymbal transducers of resonance frequency around 3kHz with different structural dimensions were designed. It was better for choosing the cymbal transducer of the 8mm cavity coping diameter, 20.8mm cavity bottom diameter and 26.8mm piezoelectric ceramic wafer diameter than others for reducing distortion degree of the signal and improving communication turnover in the researched cymbal transducers. It was appropriate for choosing the cymbal transducer of the 8mm cavity coping diameter, 22.4mm cavity bottom diameter and 26.4mm piezoelectric ceramic wafer diameter in order to improve the free-field voltage sensitivity and transmission efficient.

Introduction

The cymbal has a small volume, lightweight, high sensity, machining simple, low production cost performance, so it can be a small power transmition transducer and new sonar underwater sensor, and also can be used as actuators and acceleration sensor and so on[1,2,3]. While using for acceleration sensor, both the sensitivity and resolution are high and can be applied to ground vibration analysis, vibration stress scans and vibration table control sensitivity measuring system of faint vibration signal to improve test sensitivity of system and accuracy [4].

The performance of the cymbal transducer of the 5KHz-50KHz resonance frequency was researched in the foreign, such as sensivity, compression experiment research was did and production methods and process were introduced[5,6,7]. The electromechanical properties and vibration modal of the cymbal transducer of the 10KHz-40KHz resonance frequency were researched [8,9,10].

The cymbal transducers of eight sorts of different structure parameter of 3KHz resonance frequency were researched by ANSYS FEM in this article, finite element model is discussed, strunture parameter influence on resonance frequency is debated, and computing the bandwidth, quality factor, efficient electromechanical coefficeent performance parameters, the cymbal transducer of better comprehensive performance is optimized [11].

Finite Element Analysis and Structural Parameters Design

The cymbal transducer has the axisymmetric structure, two-dimensional axisymmetric model is estiblished to reduce storage and computing time, and analysis and calculation. The quasi-physical model of the cymbal transducer is axisymmetric, so take o as symmetry center, and take y-axis as axis of symmetry, and take xoz flat surface as symmetry in the face to build up geometric model of y-axis right half flat surface.

The model diagram of the cymbal transducer was shown in fig. 1. The relationship between the structural parameters and the resonance frequency is shown in table. 1
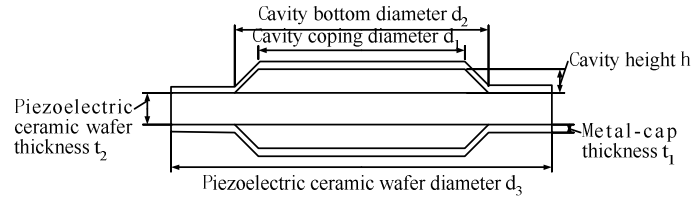
Fig. 1. Model diagram of the cymbal transducer

Table 1 The relationship between structural parameters and the resonance frequency

Sequence number	t_2 [mm]	t_1 [mm]	h [mm]	d_2 [mm]	d_1 [mm]	d_3 [mm]	f_r [mm]
1	0.5	0.20	0.5	14	18.0	24.0	2.88
2	0.5	0.20	0.5	8	22.4	26.4	2.84
3	0.5	0.20	0.5	9	21.6	27.6	3.02
4	0.5	0.20	0.5	10	22.0	30.0	2.84
5	0.5	0.20	0.5	12	18.0	24.0	3.53
6	0.5	0.20	0.5	10	20.0	24.0	3.39
7	0.5	0.20	0.5	8	20.8	26.8	3.39
8	0.5	0.20	0.5	7	21.0	27.0	3.39

    The ANSYS software is an major general finite element analysis software, it can carry on the analysis and calculation of the science of piezoelectricity and acoustics, it react on research and application field of science of piezoelectricity and acoustics. Considering axisymmetric performance, two-dimensional unit is selected in building up cymbal transducer. Building a modal according to the order of point, line, and surface.

Result Analysis

The transducer performance by calculating of ANSYS software is shown in table. 2 and table. 3.

Table 2 The simulation performance test of the cymbal transducer

Sequence number	f_r [kHz]	G_{max} [mS]	B_s [mS]	$f(B_{max})$ [kHz]	$f(B_{min})$ [kHz]	$FFVS_{max}$ [dB]
1	2.85	0.0187	0.109	2.75	2.95	-167.362
2	2.90	0.0704	0.128	2.75	3.05	-161.226
3	3.20	0.0703	0.152	3.05	3.35	-163.679
4	3.00	0.0672	0.174	2.85	3.15	-164.589
5	3.50	0.0309	0.135	3.40	3.65	-167.973
6	3.60	0.0599	0.131	3.40	3.75	-164.418
7	3.50	0.0714	0.161	3.30	3.70	-164.509
8	2.40	0.0690	0.151	3.20	3.55	-164.006

Table 3 The simulation performance test of the cymbal transducer

Sequence number	Δf [Hz]	Q_m	Q_e	k_{eff}	R_{eq} [kΩ]	C_{eq} [nF]	L_{eq} [H]
1	200	14.25	5.84	0.1090	53.53	0.073	42.62
2	300	9.67	1.82	0.2319	14.21	0.400	7.54
3	300	10 67	2.16	0.2039	14.23	0.328	7.55
4	300	10.00	2.60	0.1925	14.88	0.357	7.90
5	250	14.00	4.37	0.1268	32.39	0.100	20.63
6	350	10.29	2.20	0.2057	16.69	0.258	7.59
7	400	8.75	2.25	0.2199	14.01	0.371	5.58
8	350	9.71	2.18	0.2103	14.49	0.333	6.59

Taking the NO.2 transducer for example, the admittance modulus curve, conductance-susceptance curve and admittance circle curve were shown in fig. 2, fig. 3 and fig. 4.
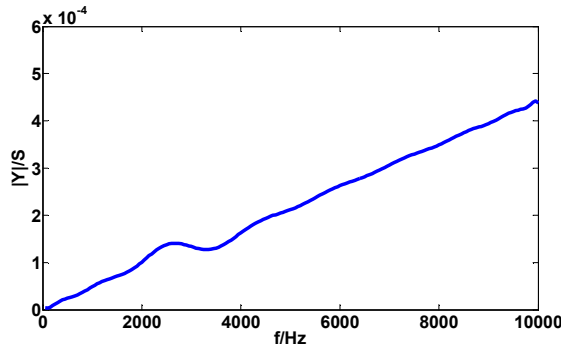
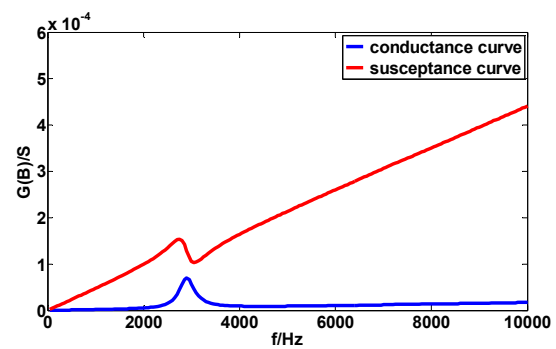

Fig. 2. The admittance modulus curve
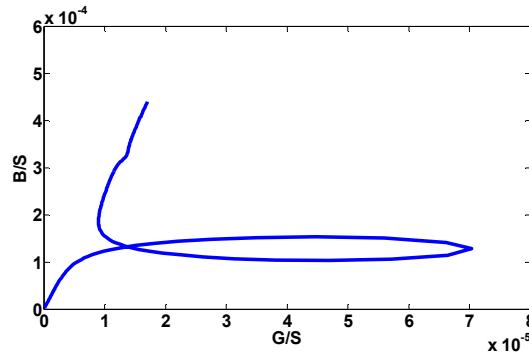

Fig. 3. The conductance-susceptance curve

Fig. 4. The admittance circle curve

The free-field voltage sensitivity of the NO.1 to NO.8 transducers are shown in fig. 5(a), (c).
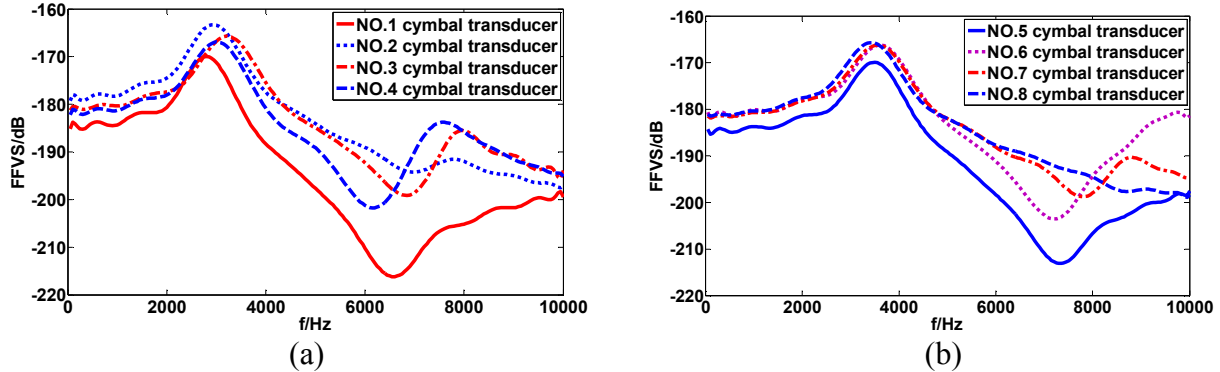

(a)

(b)

Fig. 5. The free-field voltage sensitivity curve

According to table 1 and table 2, the -3dB bandwidth of the cymbal transducer of the 8mm cavity coping diameter, 20.8mm cavity bottom diameter and 26.8mm piezoelectric ceramic wafer diameter was the broadest and up to 400Hz, the mechanical quality factor Q_m and the electrical quality factor Q_e of the cymbal transducers of the 8mm cavity coping diameter, 22.4mm cavity bottom diameter and 26. 4mm piezoelectric ceramic wafer diameter, the 9mm cavity coping diameter, 21.6mm cavity bottom diameter and 27.6mm piezoelectric ceramic wafer diameter and the 8mm cavity coping diameter, 20.8mm cavity bottom diameter and 26.8mm piezoelectric ceramic wafer diameter were smaller, thereinto, the mechanical quality factor Q_m of the cymbal transducer of the 8mm cavity coping diameter, 20.8mm cavity bottom diameter and 26.8mm piezoelectric ceramic wafer diameter was the smallest and up to 8.75, while the electrical quality factor Q_e of the cymbal transducer of the 9mm cavity coping diameter, 21.6mm cavity bottom diameter and 27.6mm piezoelectric ceramic wafer diameter was the smallest and up to 2.16. The efficient electromechanical coupling coefficient and the free-field voltage sensitivity of the cymbal transducer of the 8mm cavity coping diameter, 22.4mm cavity bottom diameter and 26.4mm piezoelectric ceramic wafer diameter were the largest,

and respectively up to 0.2319 and -161.226dB. In conclusion, the comprehensive performance of the cymbal transducer of the 8mm cavity coping diameter, 22.4mm cavity bottom diameter and 26.4mm piezoelectric ceramic wafer diameter was the best among them.

Conclusion

The performance parameters of the transducers were closely related to itself structural parameters and material parameters, it was significant superiority to design transducer by FEM. It was better for choosing the cymbal transducer of the 8mm cavity coping diameter, 20.8mm cavity bottom diameter and 26.8mm piezoelectric ceramic wafer diameter than others for reducing distortion degree of the signal and improving communication turnover in the researched cymbal transducers. It was appropriate for choosing the cymbal transducer of the 8mm cavity coping diameter, 22.4mm cavity bottom diameter and 26.4mm piezoelectric ceramic wafer diameter in order to improve the free-field voltage sensitivity and transmission efficient. Taking one with another, we can design cymbal transducer with different performance parameters according to different parameters demand.

Acknowledgements

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