

FABRICATION AND EVALUATION OF A PRESSURE SENSOR FOR THE MEASUREMENT OF A DYNAMIC PRESSURE

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Abstract: The sensor for the measurements of a dynamic pressure was developed and evaluated. Quartz was adopted as a piezoelectric medium to transmit a pressure signal and a sensor was made from SM45C. Positive going step method was used to evaluate sensors. The developed sensor showed a linear response property till 300 MPa and a repeatability error below $\pm 3\%$. The sensor showed a similar sensitivity and a poor repeatability compared to commercial pressures. But we expected our sensor had a competitiveness considering the production cost and the repeatability could be improved if the packaging technique might be improved.

Keywords: dynamic pressure sensor, quartz, SM45C.

1. INTRODUCTION

Recently, measurements of the dynamic pressure have attracted much attentions owing to needs from military service fields to businesses service fields such as a ballistics, an explosion, a blast, a shock wave, a high intensity acoustics, a hydraulics pressure and so on[1-4]. However, there are a few commercial sensors for the dynamic pressure due to the lack of understanding and the difficulty of technical development for the dynamic pressure.

In this study, the original sensor for the measurement of the dynamic pressure was developed. The conformance of the sensor model was checked by the measurement of the piezoelectric constant of the quartz used as a sensing medium. The sensor was evaluated and compared with other commercial sensors for the dynamic pressure.

2. DESIGN AND EVALUATION OF DYNAMIC PRESSURE SENSOR

The original sensor model was designed. The detailed design specification could not be described due to the business know of a co-worked company. The size of a sensor was decided considering the compatibility with the commercial measurement system for the dynamic pressure. Figure 1 shows the schematic diagrams of the fabricated sensor. The copper plates were used as a top and bottom electrode and a single crystal quartz was adopted as a sensing element. Firstly, the housing of a sensor was made

from a stainless steel but the housing material was change to SM45C due to the damage at a locking with the measurement system. The evaluation was preceded as shown in Figure 2 using a positive going step method. The pressure was applied every 25 MPa from 0 to 300 MPa and the measurement was carried by 3 times at each pressure. The applied pressures were achieved by the pressure reservoir in the measurement system and released to the sensors by opening the quick opening valve. For the comparison with the commercials sensors, PCB-119B12 and Kistler-6213B were co-evaluated with our sensors.

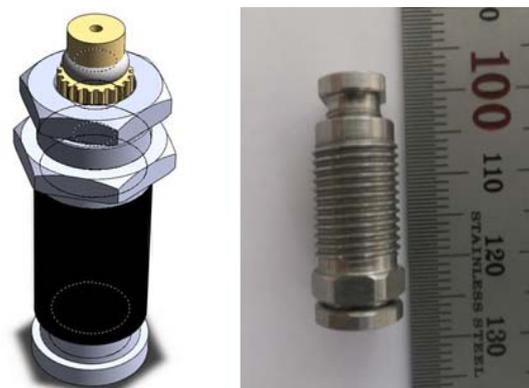


Figure 1. Schematic diagrams of a developed sensor

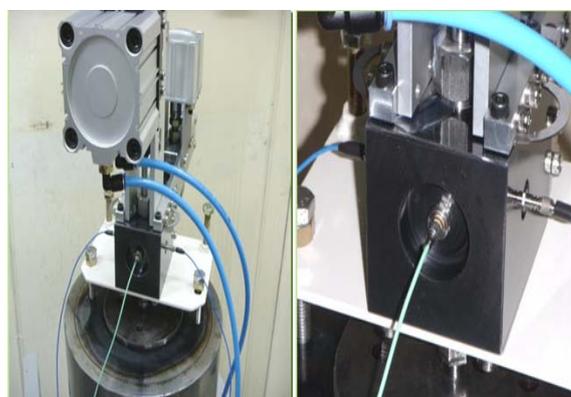


Figure 2. The locking status of the sensor with the measurement system.

3. RESULTS AND DISCUSSION

Before the evaluation of the developed sensor, we checked the piezoelectric constant of the quartz used as a sensing element to evaluate the conformance of our design. (Figure 3) The quartz showed 2.1 of the piezoelectric constant (d_{33}) and this was comparable to the reference value[5]. From this result, it was speculated that the designed sensor showed a reliable conformance as the dynamic pressure sensor. Using positive going step method, the sensor was evaluated. The sensor showed a linear response property till a 300 MPa and a repeatability error below $\pm 3\%$ (Figure 4). The sensor showed a similar sensitivity and a poor repeatability compared to commercial pressure sensors, but we expected that our sensor had a competitiveness considering the production cost (Table 1). The repeatability could be improved if the packaging and sealing technique might be improved. Also we expected that the sensitivity could be improved if other piezoelectric materials which had a higher piezoelectric constant (for example, PZT) replaced the quartz as a sensing medium.

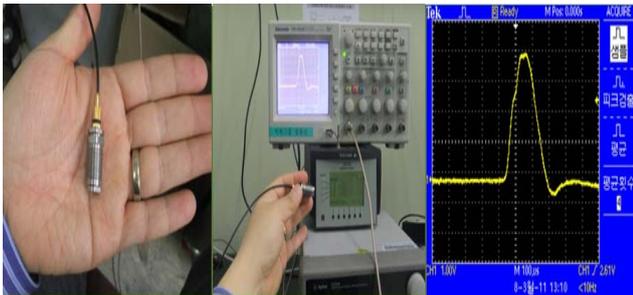


Figure 3. The piezoelectric evaluation of quartz.

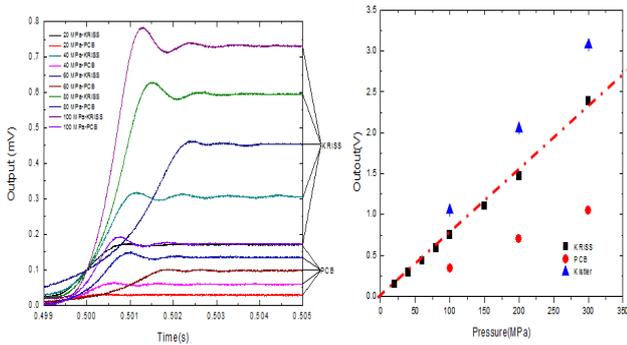


Figure 4. The evaluation of dynamic pressure sensors

Table 1. Comparisons of sensors

Sensor	KR1SS			PCB			Kistler		
	100	200	300	100	200	300	100	200	300
Applied voltage(V)	100	200	300	100	200	300	100	200	300
Output voltage(V)	0.75	1.47	2.38	0.34	0.70	1.05	1.05	2.05	3.07
Repeatability (%)	1.64	2.66	2.72	0.66	1.06	1.51	0.80	0.90	0.93
Relative cost	1			> 15			> 20		

Using our sensors, we evaluated the effect of outer temperature on the properties of sensors. We heat-treated our sensors at $1300\text{ }^{\circ}\text{C}$ for 1, 3 and 5 sec. respectively and re-evaluated our sensors. The sensor showed the sensitivity change below 6% after heat-treatments (Figure 5) and this showed that our sensors could be used at high temperature environment.

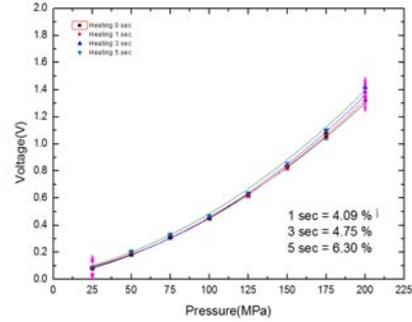


Figure 5. Heating effect on our sensors

4. CONCLUSIONS

We developed the original sensor model for the measurement of dynamic pressure. A sensing medium was a single crystal quartz and a housing material was SM45C. The sensor showed a linear response property till 300 MPa and $\pm 3\%$ of the repeatability. It showed a comparable performance to commercial dynamic pressure sensors. We expected that the performance of our sensor could be improved if the packing and sealing technique might be improved.

5. ACKNOWLEDGEMENT

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6. REFERENCES

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