論文 / 著書情報
Article / Book Information

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Title(English)	Study on underwater actuators using piezoelectric element thickness vibrations
著者(和文)	銭源
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（博士課程）
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論 文 要 旨

THESIS SUMMARY

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要旨（英文 800 語程度）
Thesis Summary （approx.800 English Words ）

This paper, entitled [Study on underwater actustors using thickness vibration piezoelectric elements] and consisting of six chapters, investigates the differences in the properties of an underwater actuator with a disk-shaped thickness vibration piezoelectric element as a result of changes in the material and shape of the thickness vibration piezoelectric element, and summarises research into the relationship between acoustic radiation force and propulsion force.

In Chapter 1 [Introduction], the miniature underwater actuators that have been studied are described, the advantages of underwater ultrasonic actuators are investigated, and the necessity of understanding phenomena such as the principle of propulsion force generation and the quantitative relationship between the two is stated for practical application. The paper states that the objective of the research is to obtain the basic data necessary for optimising the element configuration through prototype fabrication, operation measurement and analysis of three types of underwater ultrasonic actuators.

In Chapter 2 [Miniature Underwater Actuator using a PZT Disk-shaped Transducer], an actuator using a PZT disk-shaped transducer with a diameter of 10 mm, a thickness of 1 mm and a resonance frequency of 2.13 MHz is fabricated to investigate the operating characteristics and the mechanism of propulsion force generation. As operating characteristics, a static propulsion force of 1mN and a no-loaded speed of 150 mm/s were obtained for the underwater ultrasonic actuator at a driving power of 4.6 W. The propulsion force was calculated from the results of measurements of the vibration velocity characteristics of the PZT disk-shaped transducer and the acoustic radiation characteristics into the water, and from the theory of the acoustic radiation force generated at the solid/liquid boundary.

In Chapter 3 [Miniature Underwater Actuator using (Bi, Na, Ba)(Ti, Mn)O_3 Disk-shaped transdeucer], an actuator with a (Bi, Na, Ba)(Ti, Mn)O_3 disk-shaped trasducer of 8.4 mm diameter, 0.5 mm thickness and resonance frequency of 4.22 MHz is fabricated and the operating characteristics are measured to show that the disk-shaped transducers that is applied to underwater ultrasonic actuators can be constructed from lead-free piezoelectric material. As operating characteristics, a static propulsion force of 3.9 mN and a no-loaded speed of 60 mm/s were obtained for the underwater BNBTM actuator. It also shows that the underwater BNBTM actuator can be driven with a small driving power requirement of 0.4 W for a propulsion force of 1 mN. The results of calculating the propulsion force from the theory of acoustic radiation force at the solid/liquid boundary, which is already known, show that the calculated value is smaller than the measured value and that further investigation is required.

In Chapter 4 [Minature Underwater Actuator using a PZT Ring Transducer], an actuator using a PZT ring transducer with an outer diameter of 5 mm, an inner diameter of 3.2 mm, a thickness of 1.4 mm and resonance frequency of 1.09 MHz is fabricated and the operating characteristics are investigated. The PZT ring actuator's static propulsion force of 1 mN and no-load speed of 25 mm/s have been obtained as operating characteristics. The driving power for 1 mN of propulsion force is 4.2 W, which is shown to be almost the same as the value in Chapter 2.

In Chapter 5 [Equivalent Circuit of Disk-shaped Transducer], the coupling of radial vibration to the excitation of the thickness mode results in a complex distribution of vibration on the vibration surface, which is determined by analysis, and an electroacoustic equivalent circuit describing the vibration state is investigated. It is stated that an understanding of the coupling of the two vibration modes is necessary and that further study is required to construct an equivalent model.

In Chapter 6 [Conclusions and Future], the results of this study are summarised and future prospects are discussed.

In summary, this paper is an experimental and analytical study of an underwater actuator using a thickness vibration piezoelectric elements, to investigate modelling problems and to obtain basic data for the construction of an optimum system. Because this paper is the first systematic discussion of a new type of underwater ultrasonic actuator, it contributes to the realisation of underwater ultrasonic actuator applications.