DEVELOPMENT OF TRAVELLING WAVE PROPULSION MECHANISM WITH PERMANENT MAGNET VIBRATION MOTOR

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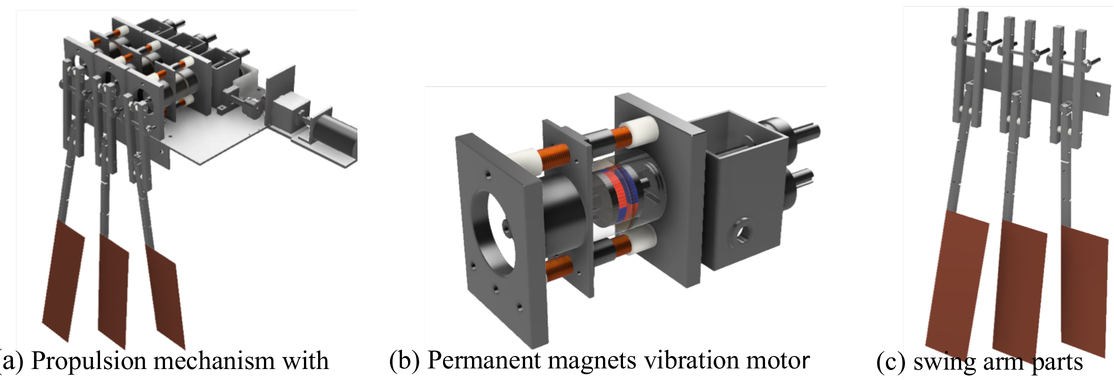
Abstract. Recently, the autonomous underwater vehicles use screw propellers as propulsion mechanisms. However, the screw propellers generate bubbles and affect acoustic measurement. Therefore, in recent years, there have been many researches on propulsion mechanisms using travelling waves imitating the permanent magnet vibration motor. By using permanent magnets for the vibration motor, it can save power consumption and drive with high thrust. This propulsion mechanism can reduce the sound during propulsion. We produced a propulsion mechanism with travelling wave and evaluated its basic structure and characteristics from the experiment.

1. Introduction

The propulsion mechanisms with travelling wave are studied for low power consumption [1] We developed propulsion mechanism with travelling wave in the past. [2] However, in past research, it is driving at high frequency and isn't known whether high frequency vibration is useful for promoting underwater. Therefore, we produced a travelling wave propulsion device of low frequency vibration. Fig.1(a) shows the geometry of the propulsion mechanism with travelling wave. It consists of a permanent magnet type vibration motor and a swing arm part. Travelling wave is generated by using three permanent magnets type vibration motors. By using a permanent magnet, the vibration motor is characterized by high thrust and low power consumption. Swing arm parts increase amplitude of vibration motor. The purpose of this study is to evaluate the basic structure and characteristics from experiment.

2. Structure of propulsion mechanism with travelling wave

The propulsion mechanism with travelling wave consists of permanent magnets vibration motor and swing arm parts. Fig.1(b) shows the geometry of the permanent magnets vibration motor. Vibration motor use two magnets with 4poles. One magnet is fixed to perform only rotational movement. The other magnet is limited only in the horizontal direction. By using springs, vibration motor utilizes spring forces. Moreover, it prevents excessive isolation between the magnets. By repeating suction and repulsion between permanent magnets, the linear motion side moves in the horizontal direction and vibrates. At the time of suction, torque is generated to promote rotation, but as the time of repulsion, counter torque is generated. By giving a phase different to the three vibration motors, it is possible to reduce the torque that hinders rotation when repulsion is generated. Fig.1(c) shows the geometry of the swing arm parts. Swing arm parts can increase the amplitude. It increases amplitude up to 36 times using principle of leverage. Also, a copper plate is attached to the tip as a fin. The copper plate has a width of 70 [mm], a height of 200 [mm], and a thickness of 0.3 [mm].



(a) Propulsion mechanism with traveling wave (b) Permanent magnets vibration motor (c) swing arm parts

Fig.1 Geometry of propulsion mechanism with travelling wave

3. Experiment

At first, we investigated the characteristics of only the permanent magnets vibration motor. When the spring balanced, the linear motion part was fixed and the thrust was measured. Fig.2 shows the relation between thrust and frequency. When the spring with a spring constant is 24.5 [N/mm], the maximum repulsive force is 78 [N] and the maximum attractive force of the spring is -79 [N]. Fig.3 shows the relation between power consumption and frequency.

Fig.4 shows the relation between thrust and frequency in the water. We confirmed the driving from 0.2 [Hz] to 5.1 [Hz]. The maximum thrust was 1.3 [N] when the frequency was 1.8[Hz]. Fig.5 shows the relation between displacement and frequency in the water in the case of the swing arm parts and 36 times the displacement of the linear motion part. Although the amplitude sharply increases at 0.9 [Hz], this is considered to be resonance. Displacement of swing arm parts decreases when the frequency exceeds 2.3 [Hz]. It is thought that the water resistance increased by increasing frequency. Moreover, it was confirmed that the device is propelled in the water.

Conclusion

The propulsion mechanism with travelling wave of permanent magnet vibration motor was produced. When the maximum power consumption of vibration motor is 1.2 [W], the maximum repulsive force is 78 [N] and the maximum attractive force of the spring is -79 [N]. The maximum displacement of the swing arm parts in the water is 79 [mm]. As a result, the device is able to output sufficient amplitude to obtain thrust underwater. We confirmed that the maximum thrust of the propulsion mechanism with the travelling wave in the water is 1.3 [N]. We confirmed that the device can be propelled in the water.

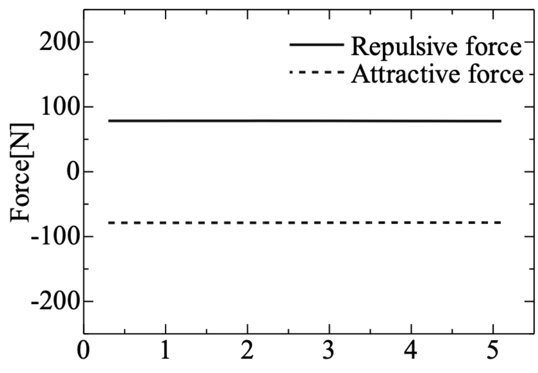


Fig.2. Relation between thrust and frequency (Only the permanent magnets vibration motor)

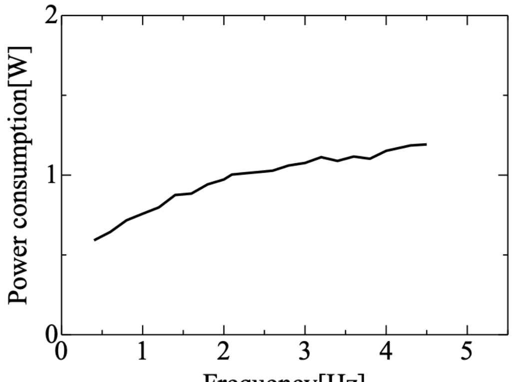


Fig.3. Relation between displacement and frequency (Only the permanent magnets vibration motor)

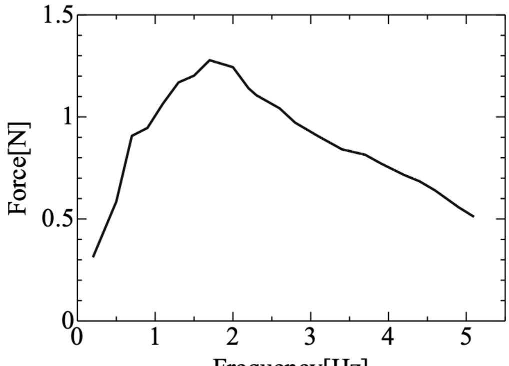


Fig.4. Relation between thrust and frequency in the water

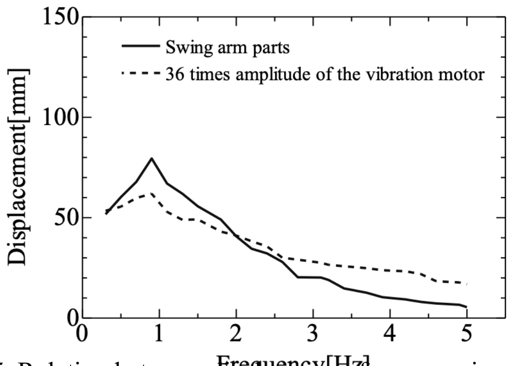


Fig.5. Relation between displacement frequency in the water

References

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