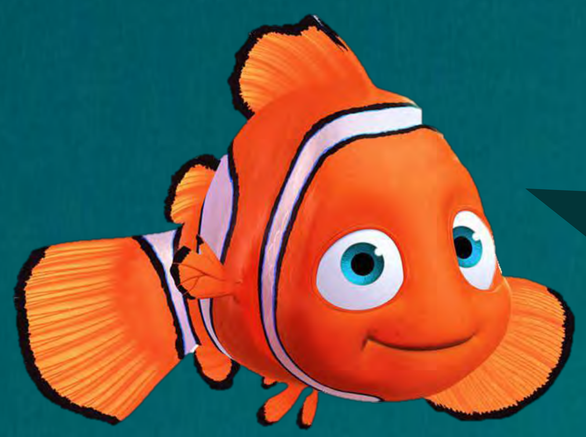

Renewable Energy Solution in Taiwan

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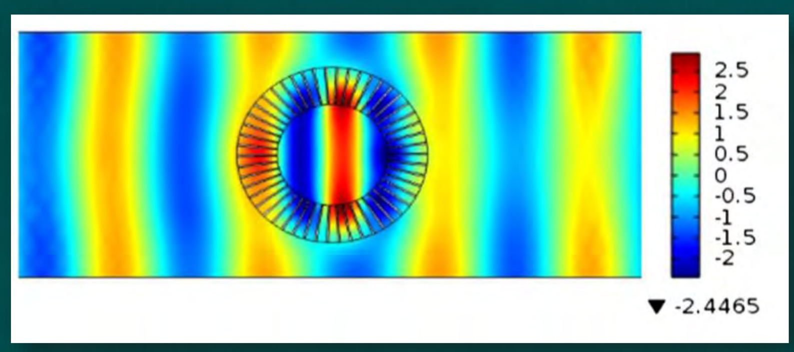
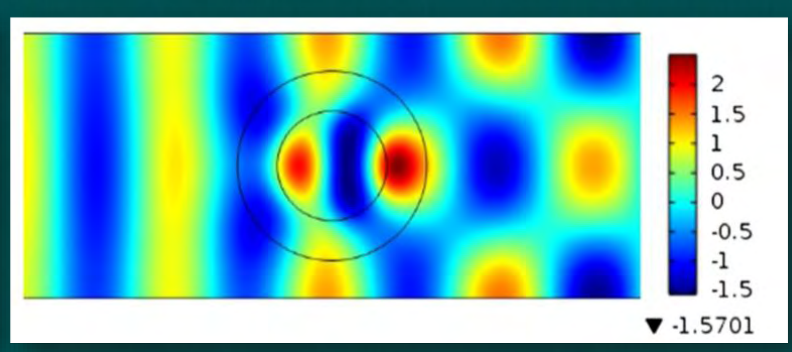
Introduction

Tidal power generation is a crucial technique on renewable resolution. However, effective harvesting is difficult due to the waves at sea level are dispersed, which requires extra energy conversion devices. In the previous literature, a designed annulus can concentrate the water wave based on Fabry-P'erot resonance, $\int_{r_i}^{r_0} n(r)dr = m\frac{\lambda}{2}$, by transformation optics and the manipulation of water waves. There are three kinds of concentrator are designed to study the concentrating effect under different baffles of concentrator and frequencies.



Concentrator with baffles

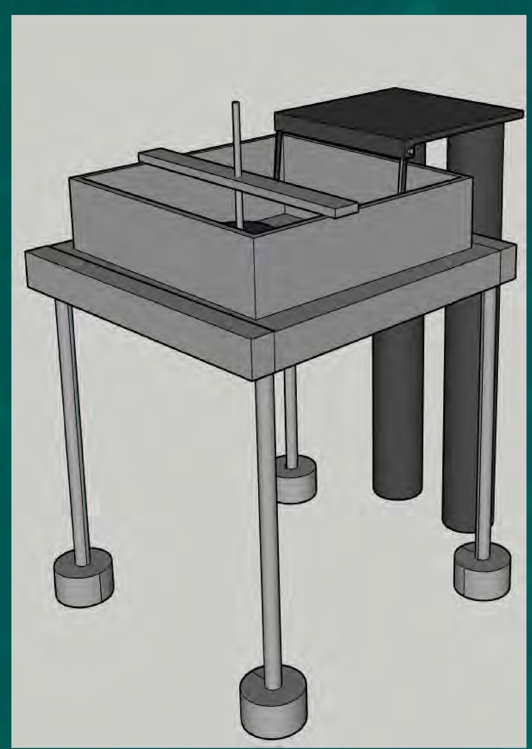


Concentrator without baffles

[1]

Set Up & Method

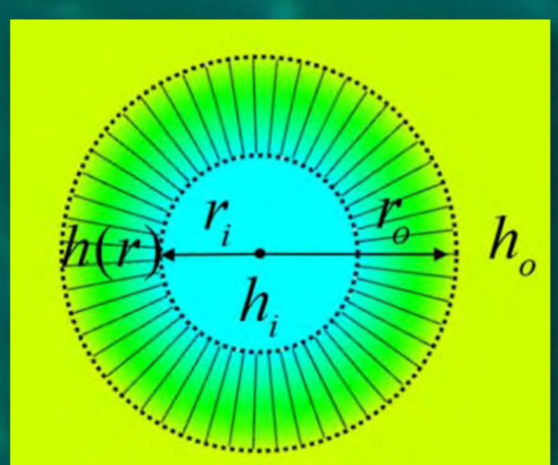
Apparatus

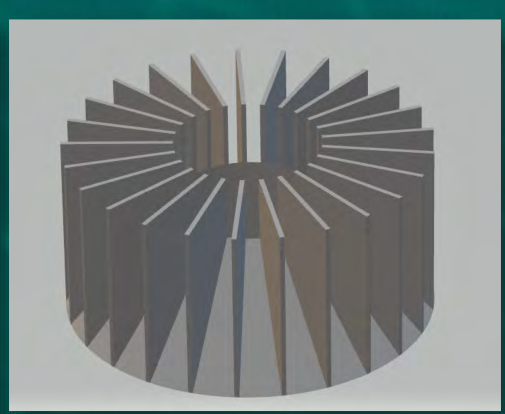


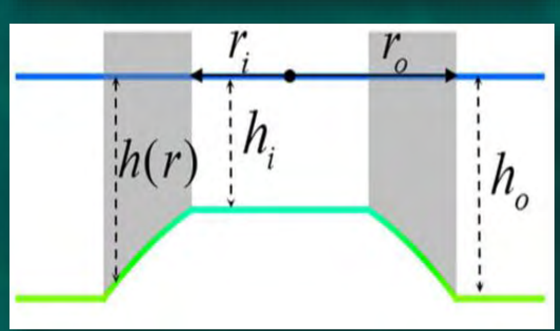
The apparatus is composed of the ripple tank, ripple generator, wave absorber, and buoy to do the experiment.

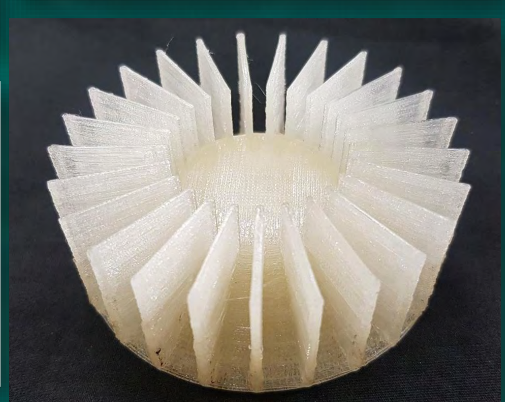
1) The ripple generator produces a plane wave, which can perform the reality waveform.
2) The strings of bead can eliminate the reflected waves. The efficiency is better than sponge.
3) The plastic stick is inserted in the middle of buoy. In this way, the area of the plastic stick can be calculated to track the motion of the buoy. Also, it will avoid the buoy sticking on the concentrator.

Concentrator

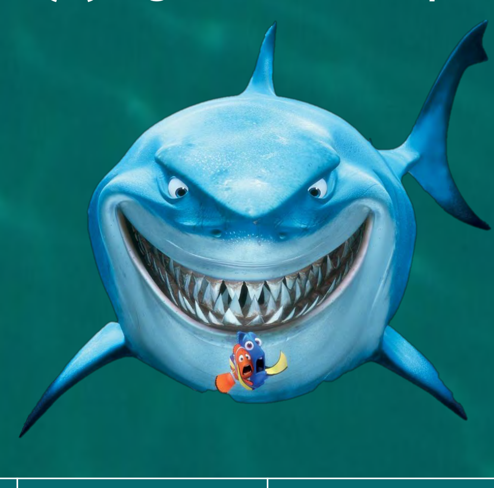








r_0: outside region
r_i: inside region
h_0: depth outside r_0
h_i: depth inside r_i
$h(r)$: gradient depth



The size and the refractive index of the concentrator can be calculated by the formulas below.

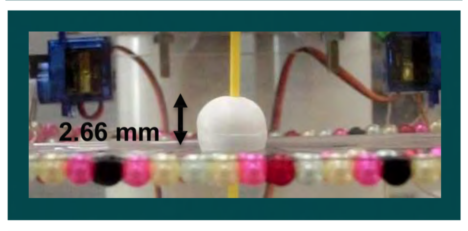
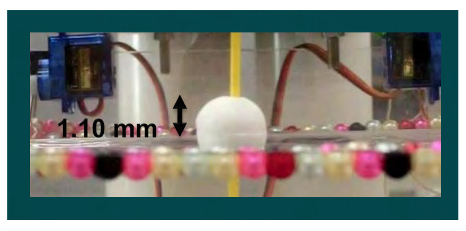
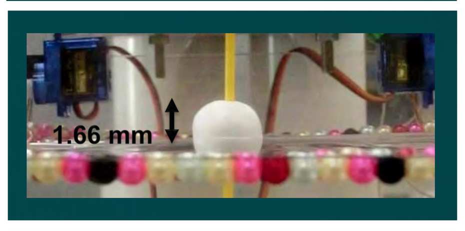
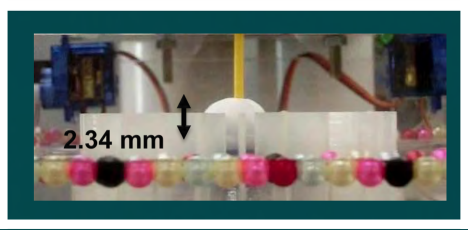
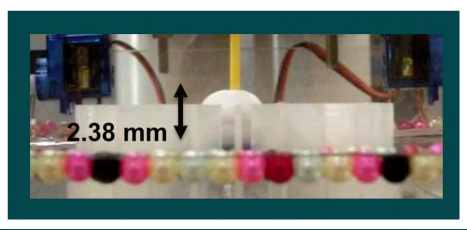
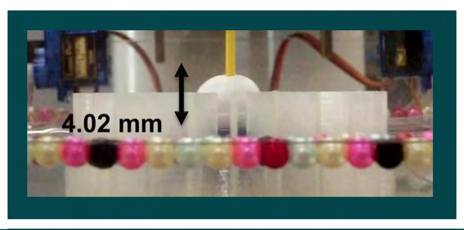
$$h_i = h_0(r_i/r_0)^2$$

$$n_i = r_0/r_i = \sqrt{h_0/h_i}$$

	20 baffles	25 baffles	30 baffles
h_i	4.7mm		
h_0	29.375mm		
r_0	31mm		
r_i	77.5mm		
n	2.5		

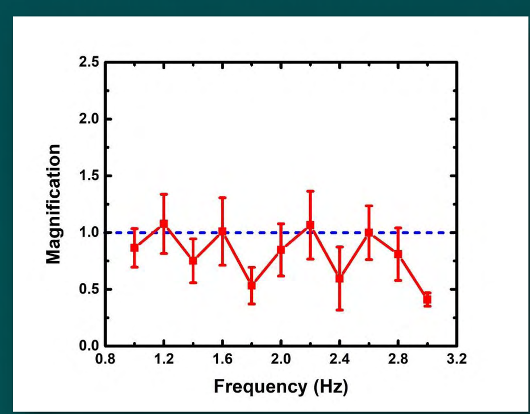
Result & Discussion

Wave Amplification

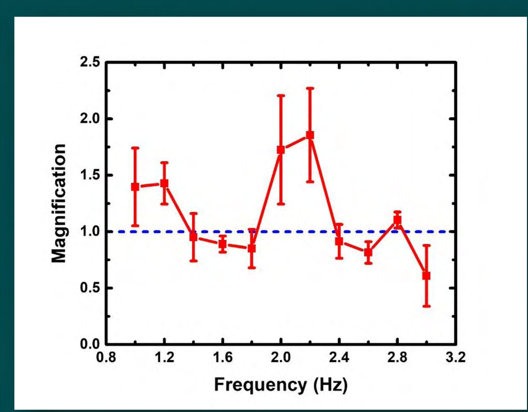
	1.6 Hz	2.0 Hz	2.2 Hz
Concentrator Without Baffles	 2.66 mm	 1.10 mm	 1.66 mm
Concentrator With Baffles	 2.34 mm	 2.38 mm	 4.02 mm

Those are the screenshots from the experimental video. The input plane waves of the ripple generator are $1.6\,Hz$, $2.0\,Hz$, $2.2\,Hz$. By observing the motion of the buoy, which is placed in the middle of the concentrator, the amplitudes are magnified under different frequencies.

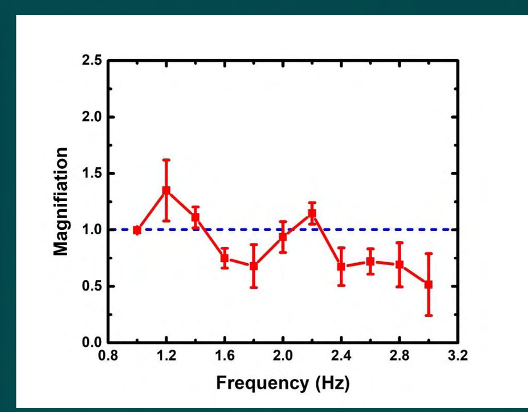
20 Baffles



25 Baffles

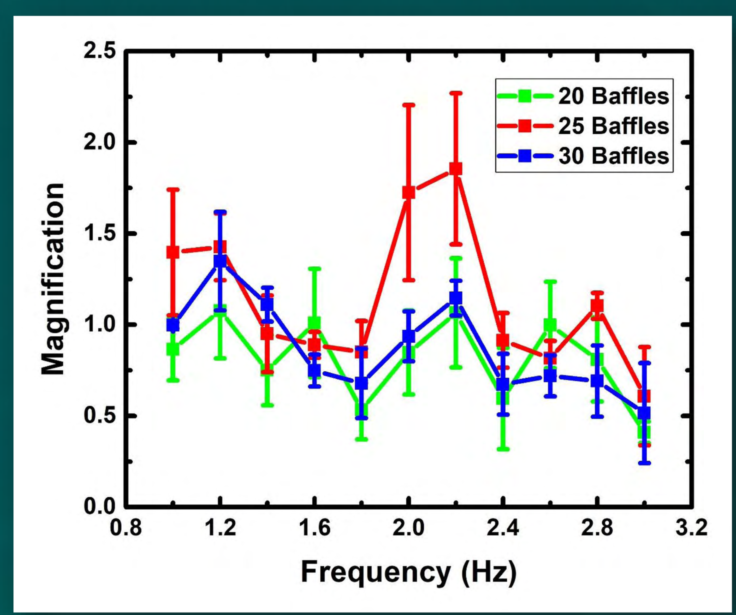


30 Baffles



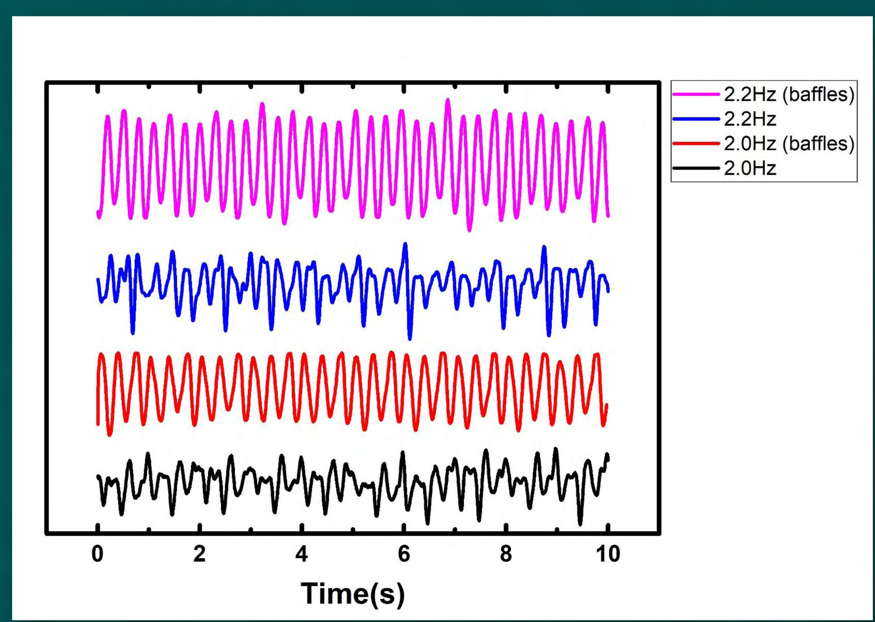
$$(\boldsymbol{Magnification}: A_{RMS,with\ baffles} \,/\, A_{RMS,without\ baffles})$$

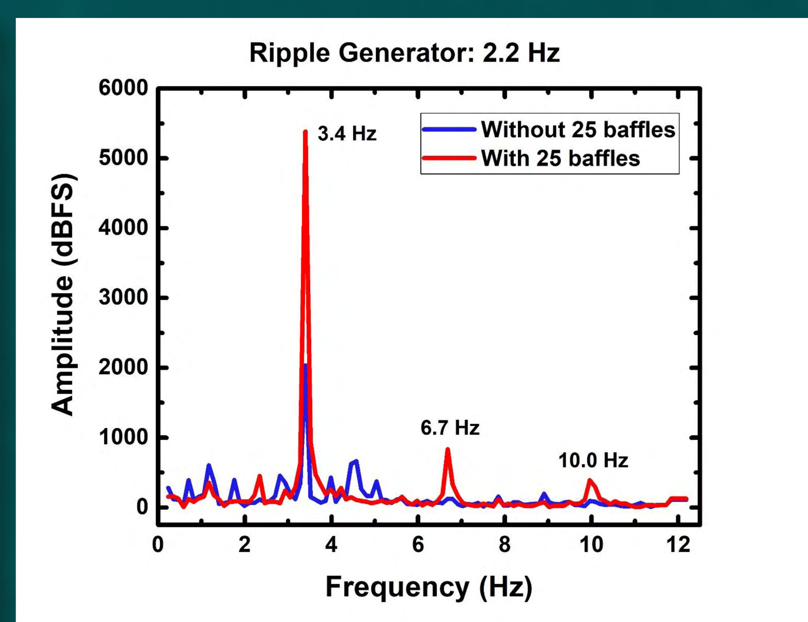
1) The density of the baffles will affect the concentrating outcome.
2) Because the width of 20 baffles is larger that the 25 baffles, the anisotropy is weaker.



3) Under the 30 baffles of concentrator, there is also a resonance; on the other hand, the concentrating effect is weaker than 25 baffles of concentrator.
4) The amplitude at 1.2 Hz or 2.2 Hz is higher than others.

Wave Rectification





1) Compare the waveform passing through the concentrator with the waveform without concentrator. The concentrator can eliminate the reflective wave.
2) Do the Fast Fourier Transformation. The waveform with concentrator has less clutter. Also, the intensity of double frequencies of $3.4\,Hz$ increase.

Reference

[1] : Li et al. Phys. Rev. Lett. 121, 104501 (2018). Concentrators for Water Waves.

[2] : https://ir.nctu.edu.tw/handle/11536/75622

[3]:https://physics.aps.org/articles/v11/89?fbclid=IwAR1tmLpVlYKuMkNIv8evlE56q0O_ae6RgUg1Os--ShS4aK190A9FdjoyjpE

Conclusion

By the Fabry-P'erot resonances, the concentrator can be designed for water wave concentrating. Also, the density of the baffles will influence the concentrating effect. To the lower density, the waveform will disperse because the slit of the concentrator is wider; in this way, the anisotropy is weak. As for higher density, the waveform will get harder to go through the slit. Moreover, the concentrator can regulate the waveform to realize the wave rectification because the concentrator will limit the passing way of waveform.