Energy from Swastika-Shaped Rotors

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It is suggested here that a swastika-shaped rotor exposed to waves will rotate in the direction its arms are pointing (towards the arm-tips) due to a sheltering effect. A formula is derived to predict the motion obtainable from swastika rotors of different sizes given the ocean wave height and phase speed and it is suggested that the rotor could provide a new, simpler method of wave energy generation. It is also proposed that the swastika rotor could generate energy on a smaller scale from sound waves and Brownian motion, and potentially the zero point field.

1 Introduction

With the recent awareness of the environmental damage caused by fossil fuels, there is a need to find renewable sources of energy. There are many possible sources of energy: sunlight, the wind, ocean tides and also the energy stored in ocean surface waves, and other types of waves. Ocean waves are particularly relevent for the island of Great Britain. It has been estimated that between 7 and 10 GW of energy might be extractable from the waves in UK waters by Wave Energy Converters (WECs), compared with the UK peak demand estimated at 65 GW, so that 15% of UK peak demand could be met by wave power [1].

One of the first viable techniques for the generation of ocean wave power was Salter's Duck which rotated along a horizontal axis under the undulation of waves and generated energy using dynamos. The result was an 81% conversion of wave energy into power [2], but this method extracts energy from waves only in one direction.

Another problem with Salter's duck and other wave energy converters is that they have many moving parts which can degrade with time. The new wave energy generation method proposed here is far simpler in structure and has only one moving part: the rotor. It can also be deployed far from the coast, and, as discussed later in the paper, is applicable to all kinds of waves or fluctuations and not just ocean waves, maybe also the zero point field.

Part of the inspiration for this paper was the proposal of Boersma [3] that two ships at sea will produce a wave shadow zone between them, so that more waves will hit the ships from outside than from between them and so the ships will tend to move together. This is an analogy to the well-known Casimir effect in quantum physics [4] which involves the suppression of the zero point field between two parallel conducting plates which are then forced together. The Casimir force has been measured [5]. The effect due to ocean waves is predicted to be small, but has recently also been measured by [6].

2 Method & results

This proposal uses a swastika, or Greek letter Chi, see Figure 1. The idea is that if waves arrive from all directions,

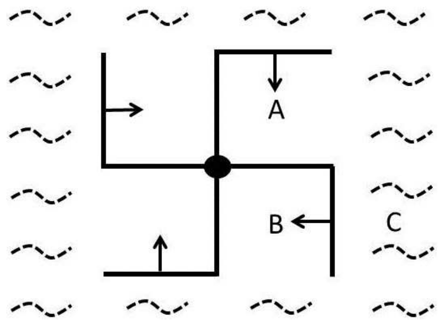

Fig. 1: Schematic showing the swastika rotor, the surrounding wave field (dashed lines) and the resulting forces (arrows).

more waves hit the outer sides of the swastika's arms, then hit the sheltered inner-facing sides of the arms, producing a torque that rotates the swastika about its axis.

To explain this more clearly and estimate the force that can be extracted from this shape we can consider three square areas that interact with the southeast arm: areas A, B and C as shown in Fig. 1. The assumption is that the areas A and B are sheltered zones rather like harbours and that only certain waves can exist between the walls, those with a wavelength that has nodes at the walls. If we then assume that the particular wavelength in the ocean does not fit, then there will be fewer waves in areas A and B, but there will of course be waves in area C since there is no closed boundary, it is open to the ocean. The maximum force obtainable from this shape can be found by looking at the net force on the southeast arm of the swastika and multiplying it by four. For the inner half of the southeast arm, between areas A and B, there is no net force since there are either no waves, or more likely the same intensity of waves, on either side, but for the outer half of the arm between B and C there will be a force on the arm pushing it westward because there are waves on the open east side, but not on the enclosed west side.

According to [7, 8] the impact pressure or slamming force (P) due to wave impacts is

$$P = \frac{F}{A} = K\rho C^2, \quad (1)$$

where A is the area of impact, K is an empirical constant between 3 and 10, ρ is the water density and C is the wave phase speed. For the southeast arm of the swastika this is

$$F = KA\rho C^2 \tag{2}$$

and A is the area hit by the waves which is the half-length of the arm (D) times the wave height h

$$F = KDh\rho C^2. \tag{3}$$

The force and resulting rotation will be clockwise, towards the arm-tips. Since $F = ma$, then the acceleration of the arm will be

$$a = \frac{KDh\rho C^2}{m}. \tag{4}$$

Equation 4 predicts the maximum acceleration obtainable from the swastika, neglecting friction, if its dimensions are such that it cancels the waves in areas A and B completely. The acceleration increases as a function of the wave height (h), length of the arms (D) and the phase speed (C). The acceleration, of course, decreases as the mass increases (m). The effect missing here is friction, which will slow the rotational acceleration as soon as it begins.

3 Discussion

This rotor is only a proposal at this stage. It requires testing in a wave tank big enough so that interactions between the swastika and the wave tank's walls are reduced and also so that the waves in area C are not damped. The waves should be a similar wavelength to the width of the arms of the swastika or shorter. Longer waves than this will not be able to resolve the shape of the arms so there will be no rotation. Eqs. 3 and 4 imply that to get the maximum rotation, the test should use a light rotor with arms projecting enough from the water to intercept the waves, subject to high waves with a large phase speed. Since the effect may be subtle, care will have to be taken to reduce the effects of residual rotational flows.

The swastika rotor has advantages over current wave energy devices in that it is simple and has only one moving part: the axle, it does not require wave impacts from any particular direction and can work just as well with isotropic random waves, and it will also rotate if a surface ocean current exists, but the opposite way, since it is then similar in design to an anenometer.

One intriguing possibility is that the rotation of the swastika shape in a wave field could also be applied at a much smaller scale. A smaller-scale swastika may be spun by sound waves, Brownian motion or even on the nanoscale by the zero-point field allowing perhaps that source of energy to be tapped for the first time.

On the Brownian scale [9] have shown that boomerang-shaped colloidal particles move towards their concave sides when subjected to Brownian motion: random collisions with atoms or molecules. A sheltering process similar to that described in this paper, might explain their results since, due to sheltering, these boomerang particles would see fewer impacts from atoms in the concave gap between their arms and more impacts on their convex side, so they should move towards their concave side, or towards their arm-tips, just as observed.

A light-driven swastika-shaped rotor on the nanoscale has already been demonstrated. It does not utilise the zero point field, but is driven by an applied beam of light and works in a different manner since the light photons interact with the electrons in the conducting shape [10].

4 Conclusions

It is predicted that a rotor in the shape of a swastika will rotate in the direction its arms are pointing, i.e.: towards the arm-tips, in the presence of isotropic waves, due to the sheltering effect of the arms.

It is proposed that such a rotor can be used to convert wave energy to electricity by using its axle to drive a dynamo. Its advantage over existing wave energy generating devices is its simplicity, its response to isotropic waves and its (reversed) response to surface currents. It now needs to be tested experimentally.

The swastika shape could also be used on smaller scales to generate energy from sound waves or Brownian motion: for example it may explain the observed motion of Boomerang-shaped particles. It may be possible to use nanoscale swastika rotors to extract energy from the hitherto untapped zero point field.

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References

1. Drew B., Plummer A.R., Sahinkaya M.N. A review of wave energy converter technology. *Proc. Inst. Mechanical Engineers*, *Part A*: *Journal of Power and Energy*, 2009, v. 223, no. 8, 887–902.
2. Falnes J. A review of wave-energy extraction. *Marine Structures*, 2007, v. 20(4), 185–201.
3. Boersma S.L. A maritime analogy of the Casimir effect. *Am. J. Phys.*, 1996, v. 64(5).
4. Casimir H.B.G. On the attraction between two perfectly conducting plates. *Proc. Kon. Nederland Akad. Wetensch.*, 1948, v. B51, 793.
5. Lamoreaux S.K. Demonstration of the Casimir force in the 0.6 to 6 μm range. *Phys. Rev. Lett.*, 1997, v. 78, 5–8.
6. Denardo B.C., Puda J.J. and Larazza A. A water wave analog of the Casimir effect. *Am. J. Phys.*, 2009, v. 77(12).
7. Bea R.G., Xu T., Stear J., Ramos R. Wave forces on decks of offshore platforms. *Journal of Waterway, Coastal and Ocean Engineering*, May/June 1999, 136–144.
8. Chen E.S and Melville W.K. Deep-water plunging wave pressure on a vertical plane wall. *Proc. R. Soc. Lond.*, 1988, v. A417, 95–131.
9. Chakrabarty A., Konya A., Wang F., Selinger J.V., Sun K., Wie Q.-H. Brownian motion of boomerang colloidal particles. *Phys. Rev. Lett.*, 2013, v. 111, 160603.
10. Liu M., Zentgraf T., Liu Y., Bartal G., Zhang X. Light-driven nanoscale plasmonic motors. *Nature Nanotechnology*, 2010, v. 5, 570–573.