An Experimental Study on Wave Energy

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Abstract

Despite the presence of methods and patents, wave energy which is one of the renewable energy sources and having great potential to generate energy, is not used in practice. The main reason for this is that the already known methods/patents recommended and used, aim to convert wave energy directly to electrical energy, end up with having low performance, high costs and the useful life of the system not meeting the costs. In this study, a new perspective has been developed and successful results were obtained in generating energy. Briefly, study is based on sea water gaining potential energy. In order to make this happen, experimental setup was designed and its prototype was produced. Ultimately, mechanical system installed on the sea and it pumped sea water 30m away in horizontal distance and up to 15m vertically without any external forces. By collecting the pumped sea water in a tank, the procedures for the operating principals of hydroelectric station are done and electrical energy is generated. Thus this earth friendly system will prevent the pollution and deforestation. Also, the system will lower the cost of energy generation.

Key words: Sea wave, renewable energy, potential, electricity

1. Introduction

The idea of converting wave energy to electrical energy has 200 years of history. For the last 30-40 years many researches had been carried out and so far, there are more than 1000 methods and patents involved in this subject [1-2]. Due to low durability, high cost and low gain the systems produced subject to these methods could not be put into practice yet.

In this study, to avoid such problems new concept has been proposed. The idea is to make sea water gain potential energy and collect it into a tank. Afterwards, the procedures for the operating principals of hydroelectric station need to be done to generate electrical energy. Due to low cost and its efficiency electricity generation from the hydro electric stations is the most common technique in this field.

The kinetic energy produced by wave is enough to lift some water to a specific height with the help of simple water pump. Depending on the wavelength and its height, transmitted water weight may vary from some grams to some liters. By considering thousands of such pump systems installed, it is possible to think as that there is a river flowing into a tank above 100-150m. In order to generate electrical energy, water having potential energy at this height should be released into turbines.

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2. Materials and Method

2.1. Construction above the sea.

The main view of tank above the sea is shown in figure 1. The construction units shown in figure 1 are the followings:

1. proposed systems, namely pumps.
2. main pipe which connects pumps to tank
3. the tank which contains water, gathered by main pipe.
4. downpipe with which water released into turbine.
5. turbine to generate the electricity.

Tank and turbine are mounted on the floor inside sea, while pumps are mounted to iron bars mounted to floor inside the sea [3].

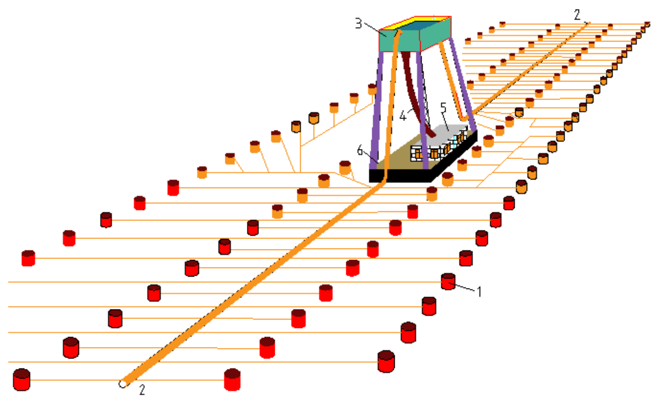

Figure 1. Tank above the sea

The working principle of system is: pumps row indicated with number 1 are designed so that they could pump the water to tank 3 with the help of wave motion. As the wave reaches a specific height, pumps start to pump up the water to tank. This action results in collection of water in the tank. By releasing water via downpipe to hydraulic turbine, water having high velocity and pressure result in electrical energy generation, by bringing electric generator into motion. Since the main mission of the system is to collect sea water into the tank above, the pumps determine the system's efficiency and the cost.

2.2. Pump Design

Lifting force acting on body sinking in the sea is

$$F_{lift} = H \cdot (\rho_{wave} - \rho_b) \tag{1}$$

The power generated by this force is

$$P_{lifting} = F_{lift} \cdot V_{wave} - M_b \cdot a_b \quad (2)$$

Where;

F_{lift} – Lifting force,

H – The volume sank into the water

ρ_{wave} –- Density of the water (g/cm3),

ρ_b – Density of a body

V_{wave} – Velocity of the wave

M_b – Body mass

a_b – Body's acceleration

As it is seen from equation 1, the weight of a body is equal to lifting force if the density of the body is equal to half of the density of the water. Thus, ascended system supported by lifting force will descend back under the same force. So, taking into consideration this fact, the system, which will be able to convert wave energy to potential energy, should be designed so that it would be possible to double the energy produced by the system.

Thus desired properties of the proposed system are as follows:

- To be double-acting.
- To have a simple construction.
- To be easy and effortless to install and to maintain.
- Durability in all weather conditions.
- To have montage units independent of construction.
- Capable of working above 0.3-0.4 meter wave height.
- To have low cost of production and maintaining.
- To be used as breakwater.
- Not polluting the environment.

2.3. Mechanism With Stable Slide

The scheme of one of the simple construction is shown in figure 2. The parts of the system are the followings:

1- Stabilizer. It is installed to sea floor.
2- Pipe. Strengthens the system.
3- Pontoon. It has a rigid structure and half filled with water.
4- Double-acting pumps. Pumps the water uphill.
5- Rope. Stretching the system.

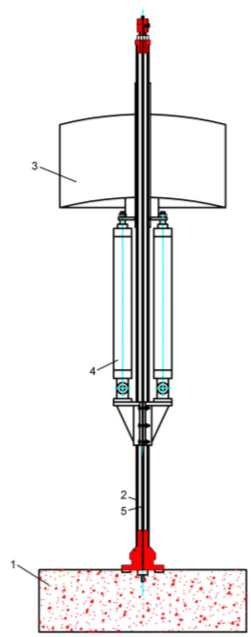

Figure 2. Mechanism with stable slide

In the experiment, due to high cost of installing the system in the sea floor, the stabilizer was filled with pebbles not allowing wave to overthrow the system. The experimental setup is shown in figure 3 and 4 as before and after the installation.

Figure 3. The experimental setup before installation, check up

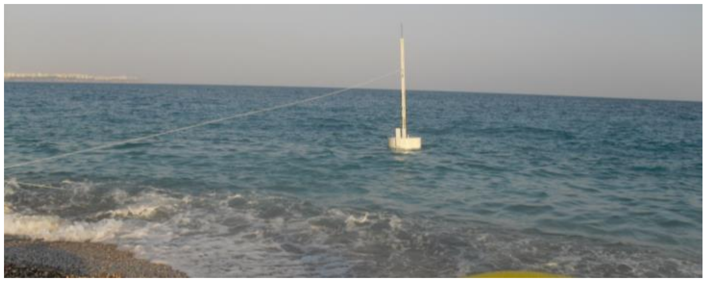

Figure 4. The experimental setup after installation

The technical parameters of the experimental setup are the followings:

- Height of the slide: 6m
- Acting force to the floor when stabilizer is filled with pebble : 5500N
- Number of pistons: 2
- Diameter of each piston: 70mm
- Free span for the piston traverse: 700mm
- Dimensions of a pontoon:
  - Diameter: 1000mm
  - Height: 400mm
- Lifting force produced by the pontoon: 3140N
- Min height of the wave needed to make the system work: 200mm

2.4. Performance computing of a mechanism

The pressure occurred on the pistons due to wave motion with height 200mm is calculated as below.

$$P = F_{lift} \big/ A_{piston} = D^2 \cdot h_f \cdot \rho_w \big/ 2000 \cdot d^2 \tag{3}$$

Where;

A_{piston} – Cross-sectional area of a piston.

D – Diameter of a pontoon.

h_f – Depth of water to which a pontoon sinks

d – Diameter of a piston.

At the end of calculation the value of P is equal to 2bars.

The waves in the sea are irregular and due to the existence of friction forces, the measured pressure is always below theoretical computation. Also, due to half filled pontoon with water, there occurs an inertia force acting backwards direction of the system motion with the motion of wave.

By neglecting inertia forces the power gained from the wave with height of 200mm is:

$$W = F_{lift} \cdot V = 1570 \cdot 1 = 1570w \quad (4)$$

Where V – is the average rate of the rise of the wave. Average value of V is greater than 1m/s. Denoting wave period by t, the system's average power is computed as below.

$$W_{ave} = W_t / t \quad (5)$$

3. Results

Experiments were carried out in Konyaaltı Beach, Antalya/Turkey. The pistons are mounted on the bottom of pontoon. By doing so, it was possible to make slide stay vertically. The system started to work no less than 200mm of wave height and pumped the water to the beach. As it is seen in figure 5 and 6, the system worked perfectly for a low-level wave.

Figure 5. Result of the application and water flow on the beach

Figure 6. Result of the application and measuring the pressure

Two parameters have been planned to be measured during the experiments. These are the pumps' flow rate and the pressure they produced. Considering sea wave height having 300-400mm height, the observations made, verify that the occurred flow rate was capable to produce 0.3 – 0.5kW of power. It is also observed that peak pressure value was 1.5bar and the average pressure value was 1.2 bar (figure 7).

Figure 7. Measuring the pressure

4. Discussion

Sea waves have a great potential energy. According to computations the estimated potential power across the oceans is 30million – 1billion MW [7]. Nevertheless, it could not be used for humanity. The proposed system with its simplicity and low cost production [4], aims to solve the task.

In the open sea, wave is not continuous and can produce only small amount of energy for a single wave pass. Yet, the kinetic energy produced by the wave is enough to raise the water to a certain height. Depending on the wave length and height, pumped water may reach up to several liters. Considering thousands of proposed system installed, water can be pumped up to 100 – 150 meters above sea level into the tank. To convert this potential into electricity one should release the water into the turbines.

Conclusions

In the scope of work having special construction, the double-acting system has been designed and experiment results obtained which are summarized below:

- The system works double-acting way.
- Mechanism is so stable that regardless wave level, it does not escape from vertical axis of a system.
- The pontoon must have rigid structure
- Efficiency parameters of a system overlap to those in theoretical ones.
- Minimum wave height needed is 200mm to make the system work.
- Flow rate of the system: ~$0.4m^3/h$
- The pressure system produce:
  - Peak value: 1.5bar

  - Average value: 1.2bar
- Horizontal distance of transmission of the water: 30m

References

[1] Bilim ve Teknoloji Platformu. Website. -http://www.bilisimgelisim.com/bilim-teknik/21-dalga-enerjisi.html#ixzz269xUYfTL, access: 10.09.2012.
[2] SDE – 2012, Website. http://www.sde-energy.com/107EPESWIKI_29_2_12.pdf, access: 08.05.2012.
[3] Abdulla, G., Denizde Meydana Gelen Dalga Hareketleri Yardımı İle Yapay Nehir Oluşturulması, *IV. Ege Enerji Sempozyumu*, İzmir, 2008.
[4] Abdulla, G., Kodaloğlu, M., Abdulla, R., Abdullayev, R., Dalga Enerji Sistemi, Ispartek Proje Pazarı,SDÜ Isparta, 2012.
[5] Сичкарев В.И., Акуличев В.А. Волновые энергетические станции в океане. -М.: Наука, 1989.-132с.