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EXPERIMENTAL STUDY ON OVERTOPPING PERFORMANCE OF A CIRCULAR RAMP WAVE ENERGY CONVERTER

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ABSTRACT

One of the most important debates on energy is planning for the best carriers in each region and determined based on each country's energy basket. The importance of preserving fossil resources becomes evident when we made the prediction. Iran's oil and gas resources will finish up to 136 years to 79 years. Since the clean energy production is a new source in interested field of researchers. Here we study the performance of overtopping with a circular ramp which can be used as a model of wave energy converter.

1. INTRODUCTION

Reduced supplies of fossil fuels are the switch to renewables. The gas production in 2040 to a peak of 65 billion cubic meters per day and this amount is reduced to zero, so that in the year 2085 [1]. The Great Britain is the leading countries in the use of renewable energy. Marine energy is an important part of this energy. Development of energy derived from renewable energy sources in Great Britain under in a hundred years future. According to the table in 2020, renewables account for 30% of total energy production by 2100 this figure will reach 80 percent.

About 6 Giga-tons of carbon in the atmosphere is produced and distributed every year [2]. Developing countries must be considered that the amount of carbon emissions over time, and because of their economic and social development, is increasing [3].

Per capita consumption of energy in developed and developing normally, due to high per capita income and the possibility of having more diverse energy devices and equipment, is greater. At the same time productivity is on the rise in recent decades has led to moderating energy consumption. Per capita consumption of final energy in agriculture, residential and commercial, public, transportation and industrial 2/3, 8/1, 6/1 and 5/1 times the average world-wide. The global average per capita consumption is lower than other carriers. This low productivity in operation, high energy consumption and using energy derived from goods and services. Per capita consumption in countries such as Turkey, India, China and Hong Kong, Pakistan, Africa, Venezuela, non-OECD Asian countries and the Middle East from Iran is lower [4].

In general, the latent energy in the seas and oceans are classified into the following five drivers are:

1.1. Energy Lies in the Tidal Energy

Moon and sun gravitational field effects on the Earth's which observed in a large bulge at sea level, is called the tide. Tide height difference between the energy produced to be effective, highest elevation can be found in bays, rivers run into the sea and searched. To attract this energy, the clause or small dams to contain the water (in the tide) is used in ponds.

1.2. Sea Flows Energy

Adsorption of solar energy and creating a temperature difference between two points of the sea, the sea currents are, of course, the phenomenon of tides, salt concentration and natural factors on the severity of an impact. The maximum speed of the movement can be found in the mouth of bays, waterways, between the islands and continental coast and the Strait searched. Large fixed and floating licenses are installed in the course of this process is the best option for extracting electricity from marine energy potential [5].

1.3. Thermal Energy of the Sea

When go deep into the sea as the temperature decreases, the temperature difference can be produced by energy converter sea thermal energy. The idea of using ocean thermal energy was expressed in 1881 by French engineer named Jagvys and the first unit was built in 1930. Although the device was destroyed by the storm, but after that it works with success [6].

1.4. Sea Waves Energy

The effects of wind and storm on the sea, waves produced, which has high power and energy, for example a wave with a height of 5.2 meters and a 10-second period power is 30 kW per unit wavelength. Waves characteristics such as height, wave period, time period and windy dependent function of wind speed and length (distance where the wind is at sea level) is, it is shown in the following figure [7-10].

1.5. Biomass

One of the main sources of biomass among renewable energy sources is included. There is a variety of definitions of these resources. The definition of the Union of Europe of biomass in the guide 2001/77 EC to September 27, 2001, the expressed, is: Biomass is part decay-able bio-products, wastes and agricultural wastes (including plant materials and animal), forestry and related industries as well as industrial waste and urban decay-able. Based on the scientific definition provided for in the Regulations biomass, biomass fuels refers to the mass of phytoplankton and zooplankton mass produced.

In this study we conducted on performance of a circular ramp on wave energy converter Wave Dragon.

2. GENERAL DESIGN ASPECTS

The most important factor, the difference in height is the state of the tide. The amount of energy extracted is proportional to the power two of amplitude. Tide in ocean height difference of about 1 meter or less. However, factors such as height near the coast to the coastline, water depth, latitude and profile will depend on the sea bed. Another important factor is the area of the tank. Consultant's tidal energy storage ponds and bays as water are available. These are the larger tank will be more energy available. The tighter the mouth of the reservoir, dam usually requires appropriate places mentioned conditions, bays, rivers entering the sea and estuaries are small. In this context, other parameters such as distance to consumption of energy, current logging ponds, hence the lack of it, away from the waves, the possibility of using the lake created for other purposes, proper depth, should be considered.

Since the Caspian Sea tidal actually there, so research has been done on the southern coast of the country. Shatt Al-Arab estuary mouth of Moses and 04/4 respectively with the tide height difference, 18/3, 60/2, 53/2 meter and the average annual potential power 92/0, 57/0, 38/0 and 36/0 Watt m were most favorable areas.

On water temperature and sea surface temperature changes with increasing depth and reliable information does not exist and therefore cannot explicitly be commenting on it. However, due to the deep water of the sea and connecting the Caspian Sea to the Indian Ocean, the Indian Ocean since the OTEC is a potential. Therefore, we can expect this sea of OTEC has the potential for use.

Since the southern coast of Iran, there is the problem of fresh water (especially in Sistan and Baluchistan) using open cycle or a combination of them in addition to electricity, fresh water will be produced, is recommended.

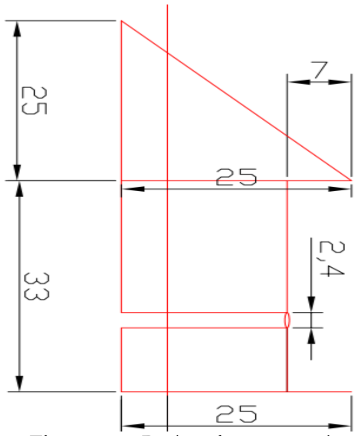

Figure-1. Designed overtopping ramp of the Wave Dragon [11].

A simple relationship between the size of wave energy converter devices and there is no price. In order to properly evaluate the relevant economic factors need to be taken into account. The cost to fix floating structures usually considers the sea floor about 10 to 15 percent of total investment. The cost of the systems fixed to the sea floor will be about 30% of the total investment.

Foundation wind and wave energy devices will act as artificial corals and biomass locally for a number of organisms increases sticky and unable to move. Marine organisms in sea water are absorbed by rigid structures. Artificial substrates may lead to physical and biological changes are the habitats with soft soles. Physical changes, changes in currents and waves to the accumulation of organic matter in the sediment size distribution in this area helps, change creates. Biological changes, cause change in biodiversity, abundance and biomass. The artificial corals due to greater protection of fisheries create new food sources and increased productivity is feeding the abundance of most species.

A removable wave power energy by ocean surface, which can be used to do useful things such as power generation, water desalination and water pumping is used. However, power generation from waves are developing a technology is commercially although efforts have been using it since 1890. In many parts of the world, wind energy has great potential to create a continuous wave which becomes the ocean waves. Energy recovery devices extract energy directly from the surface of the waves, ocean waves or from pressure fluctuations below the surface of the sea. Wave energy is significantly different in different parts of the world, as a result of wave energy can be harnessed effectively everywhere. Overall, the average turnover Wave Power wave energy through a vertical plane with unit width, parallel to the crest of the wave to be considered and known as wave energy flux is shown by the following equation:

$$P = \frac{\rho g^2 T H^2}{32\pi} \quad (1)$$

where P is wave power per unit [kw / m], ρ is the density of sea water per unit [kg / m^3], g is acceleration of gravity at the unit [m / s^2], T is wave period in units [8] and H is unit height in [m] wave breasts that are the highest point to the lowest point in the waveform.

Waves are generated by wind blowing over the surface of the sea. When the wind speed is less than the speed of propagation, the transfer of energy from the wind to sea is be done above sea level. Air pressure difference between the wind direction and wave crest as well as the friction on the water surface caused by wind shear stress, which causes the waves are growing. Wave height is determined by wind speed and duration of the wind. For example, the distance driven by wind and topography of the sea floor depth may be focused or scattered energy of the waves. In general, larger waves, more powerful wave power by the wave speed, wavelength, and water density is determined.

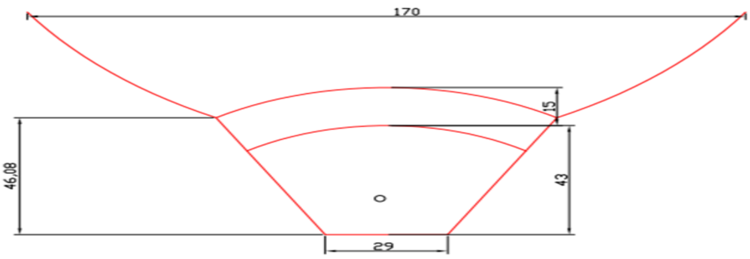

Figure-2. Schematic of the top view of Wave Dragon [11].

Wave Dragon-shaped device that affects the dimensionless wave period is as follows:

$$Q_N = \frac{1}{\lambda_{dr}} \frac{Q}{b\sqrt{gH_s^3}} \quad (2)$$

constant λ_{dr} is the ratio of the free surface .

By floating test in wave dynamics model based on similarity parallel kinematic model), the same height and amplitude of incident wave height and wave amplitude pond floating sea (waves geometric similarity), the Froude number Froude number of incident wave sea wave pool to float (parallel kinematic wave), then the dynamic similarity between model behavior in the wave pool and floating in the sea wave is established. In other words, all linear motion is modified to linear motion of the float smaller scale. All angular movements model angular movements of vessels. All the phase difference between the movement and the wave model is floating. All the absolute motion of the ship is similar to the absolute movement of points on the model. All the absolute speeds of the ship are similar to speeds against the absolute points on the model. All the absolute acceleration of the ship to the absolute acceleration points on the model.

2.1. Geometric Similarity Model

$$\frac{L_s}{L_m} = \frac{B_s}{B_m} = \frac{T_s}{T_m} = \lambda \quad (3)$$

$$\frac{A_s}{A_m} = \lambda^2 \quad (4)$$

$$\frac{\nabla_s}{\nabla_m} = \lambda^3 \quad (5)$$

$$\frac{I_{ys}}{I_{ym}} = \lambda^5 \quad (6)$$

$$\frac{I_{xs}}{I_{xm}} = \lambda^5 \quad (7)$$

Where L, B, T are the length, width and draft float respectively. Indices s and m respectively are floating and models. and ∇ , A, respectively are mass displacement and float to the surface. I, λ as well as the moment of inertia are mass scale.
Similar also is intended to float in the wave pool is created.

2.2. Wave Geometric Similarity

$$L_{Ws} = \sqrt{\lambda}.L_{Wm} \quad (8)$$

$$h_{Ws} = \sqrt{\lambda}.h_{Wm} \quad (9)$$

And so is the wave height and wave length. Parallel kinematic with kinematic wave model based on the following move.

2.3. Kinematic Model Similarity

$$V_s = \sqrt{\lambda} V_m \quad (10)$$

2.4. Kinematic Wave Similarity

$$T_{Ws} = \sqrt{\lambda} T_{Wm} \quad (11)$$

$$\omega_s = \frac{1}{\sqrt{\lambda}} . \omega_m \quad (12)$$

$$\omega_m = \frac{2\pi}{T_m} \quad (13)$$

V is the speed of floating. The angular frequency and wave period are T_W , ω respectively.

Table-1. Similarity between the model and real samples

actual samples	parameter
λ_p	length
$\lambda_p^{0.5}$	time
$\lambda_p^{0.5}$	Speed
λ_p^{3}	force
$\lambda_p^{3.5}$	Power

3. EXPERIMENTAL RESULTS

A model of a wave energy converter of Overtopping is designed and built with the following dimensions. The test simulated periods of three wave 5 seconds, 7 seconds and 10 seconds with 5 centimeters height, 7 centimeters and .09 meters wide. The reason for this wave conditions, compared to the current passing through the turbine, the inflow to the reservoir and power is generated. Draught of the devices in all tests constant 5 is centimeters. Figures 3-29 presents the measured voltage versus time in various wave height and various periods. Figures 3, present turbine output power with respect to time in regular waves to 0.05 meters high and the period of 5 seconds. As it is clear from this graph maximum output power of the moment 9mWatt and 5 mWatt is the lowest power produced by the turbine for the 0.3 volts average. The average output power device is about 7mW calculated. Figure 12 present pressure in the tank floor 0.05 meters high and the period of 5 seconds. According to the graph at the bottom of the tank maximum pressure of 452 kPa and a minimum pressure of 251 kPa is recorded. Average reservoir pressure of 391 kPa is recorded in the time span of 5 minutes. The pressure inside the tank water level in the reservoir is dependent on the type of hydrostatic pressure. Figure 21 present flow rates passing through the turbine in .05 meter wave height and period shows 5 seconds. As is clear from the graph maximum discharge of 6.0 liters per minute turbines and recorded a minimum of 5.0 liters per minute. The average discharge in the range of 5 minutes 0.596 liters per minute is calculated. The amount of input energy in each wave period equal to $E_{in} = \frac{1}{8} \rho g H_s^2 . d$ since the relationship between watts and efficiency equal to the 16 percentage specified.

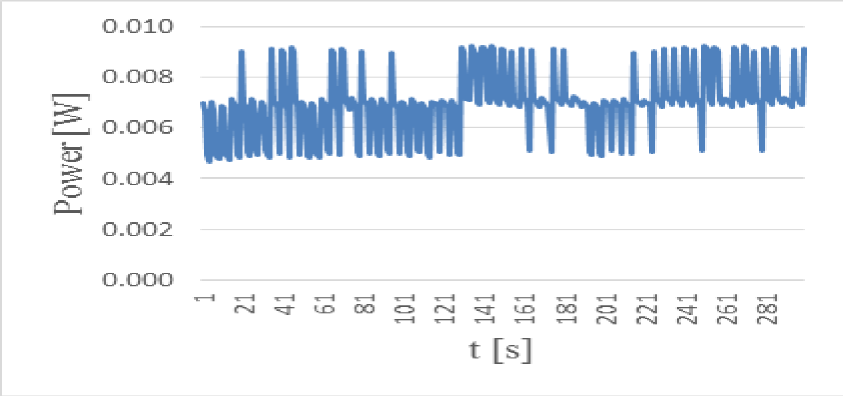

Figure-3. Measured power versus time in 5. centimeters wave height and period of 5 seconds

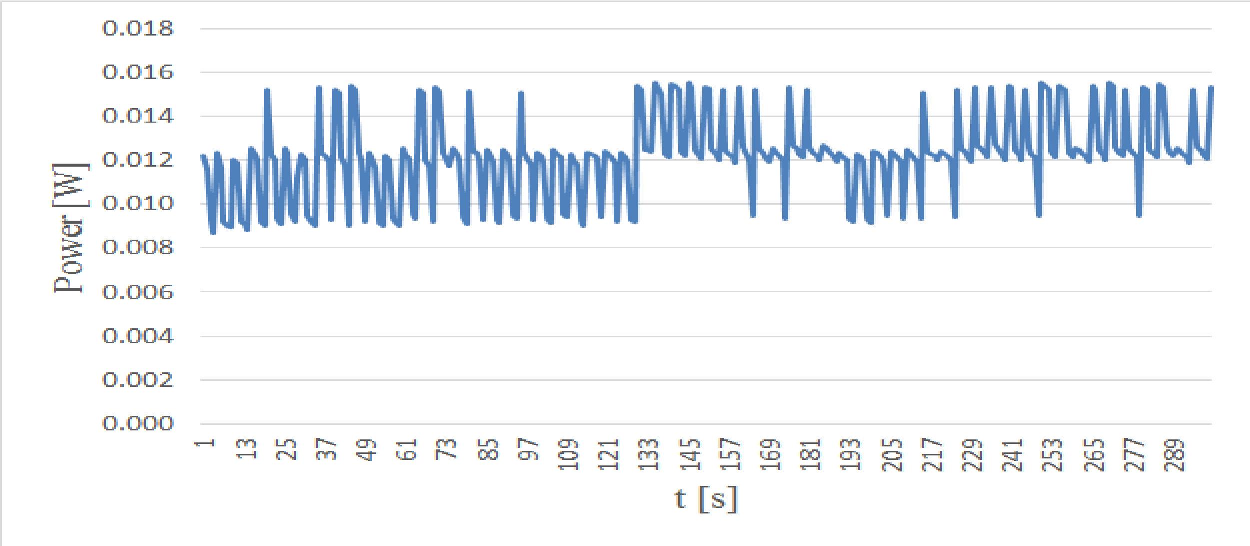

Figure-4. Measured power versus time in 7 centimeters wave height and period of 5 seconds

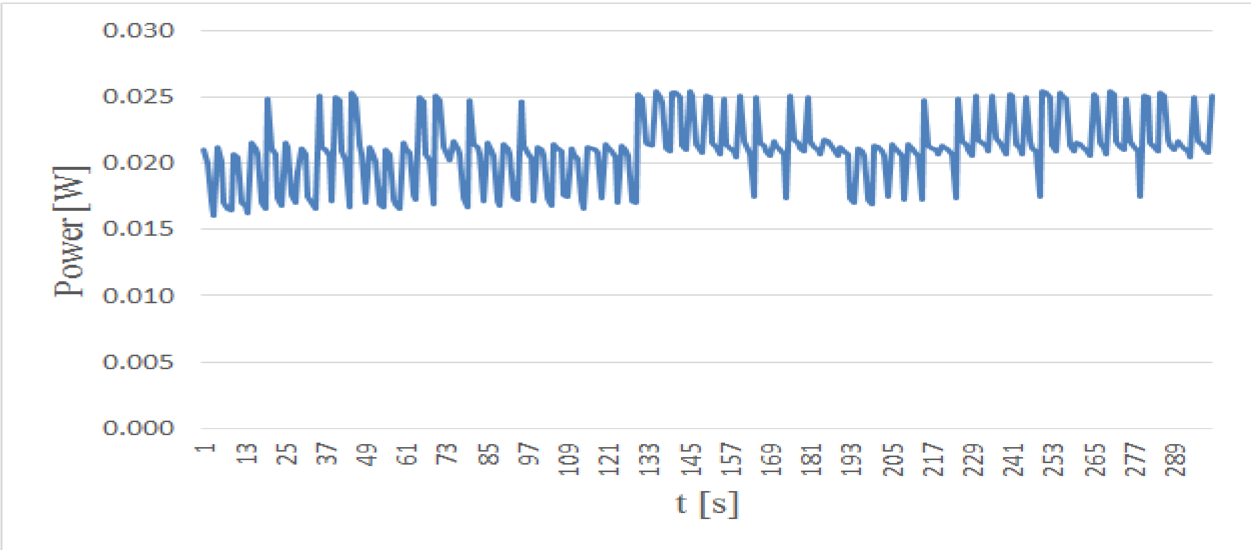

Figure-5. Measured power versus time in 9 centimeters wave height and period of 5 seconds.

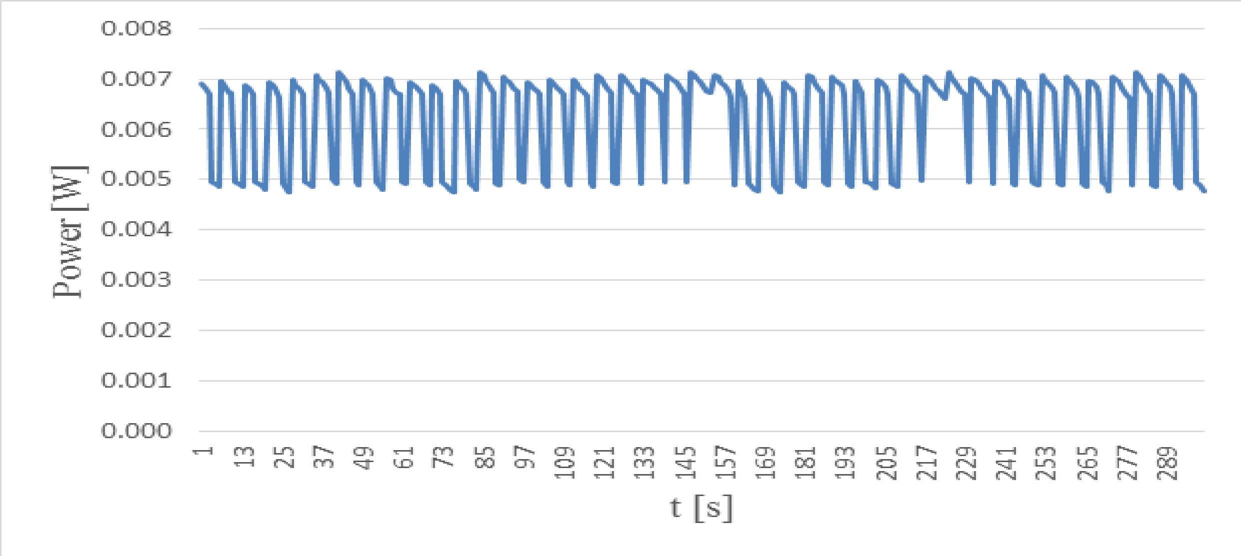

Figure-6. Measured power versus time in 5 centimeters wave height and period of 7 seconds.

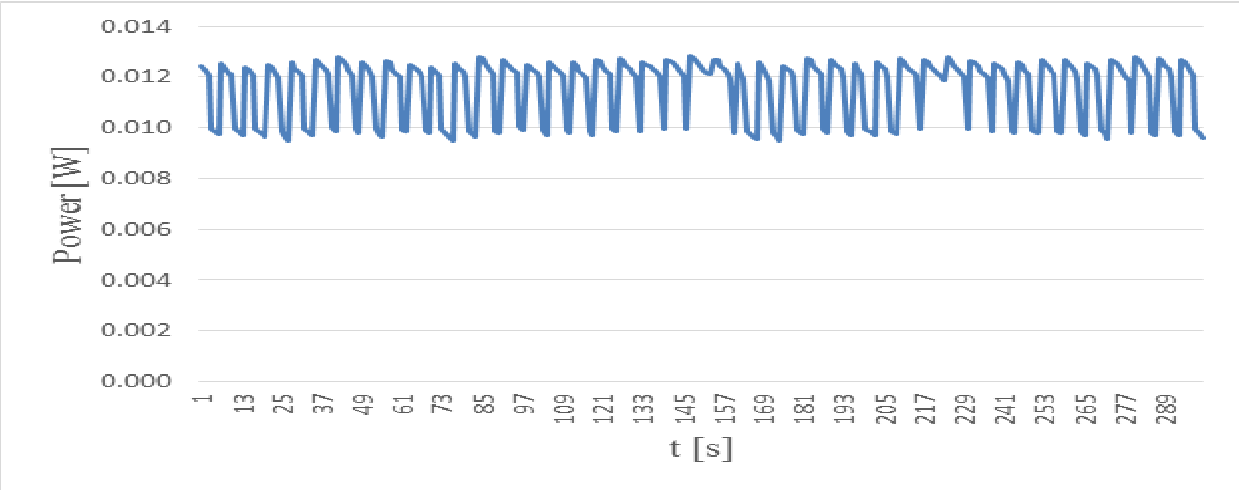

Figure-7. Measured power versus time in 7 centimeters wave height and period of 7 seconds.

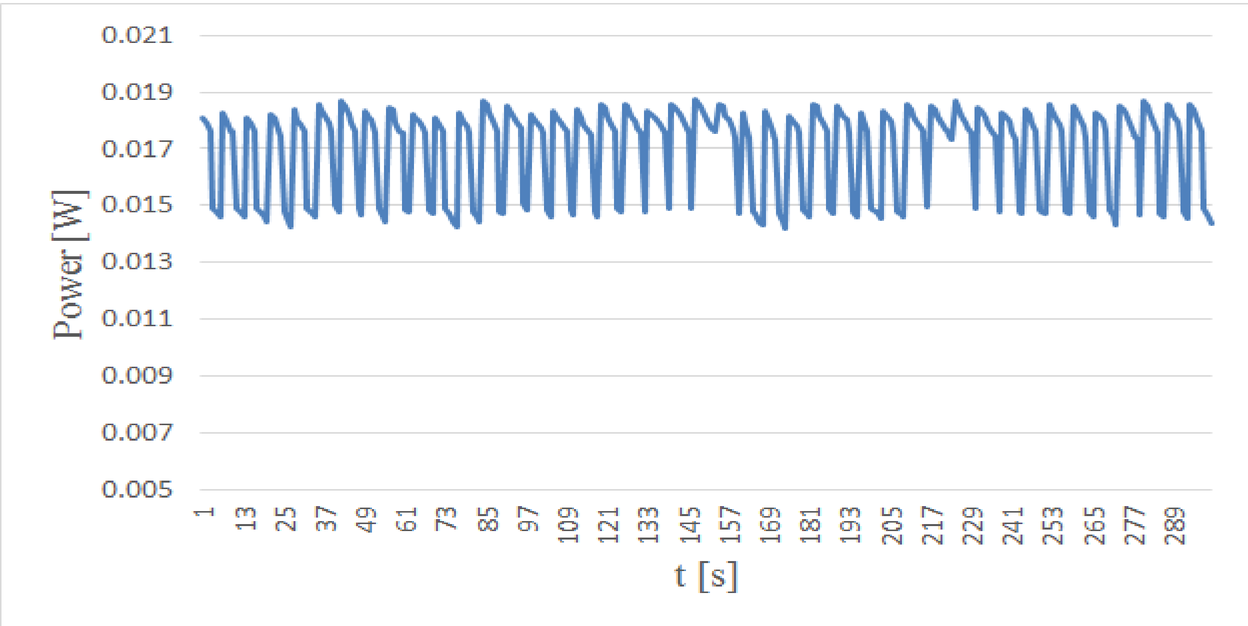

Figure-8. Measured power versus time in 9 centimeters wave height and period of 7 seconds.

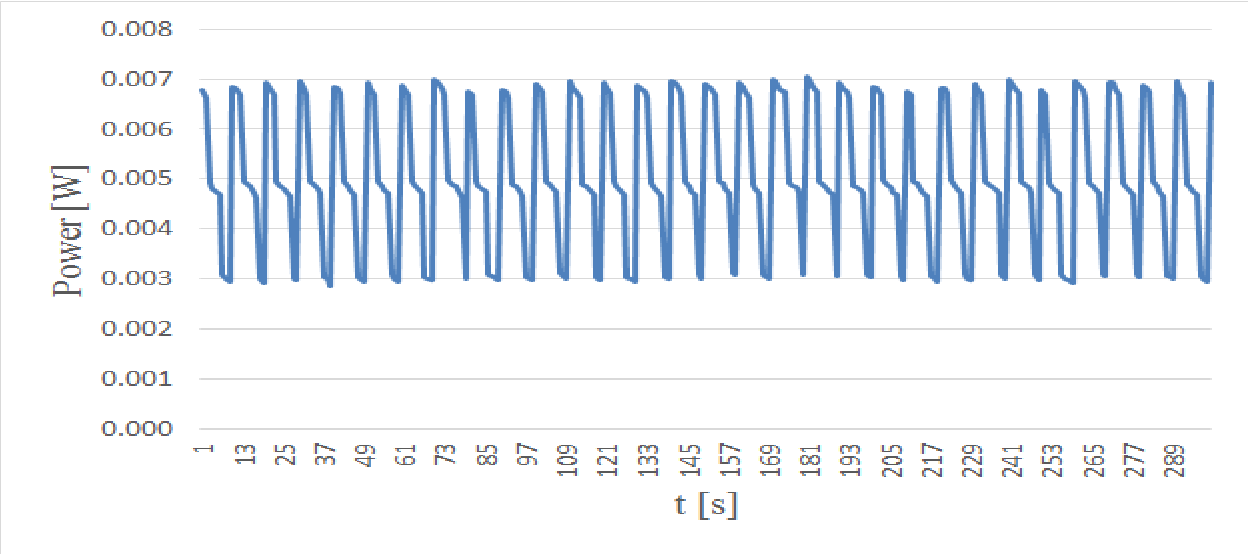

Figure-9. Measured power versus time in 5 centimeters wave height and period of 10 seconds.

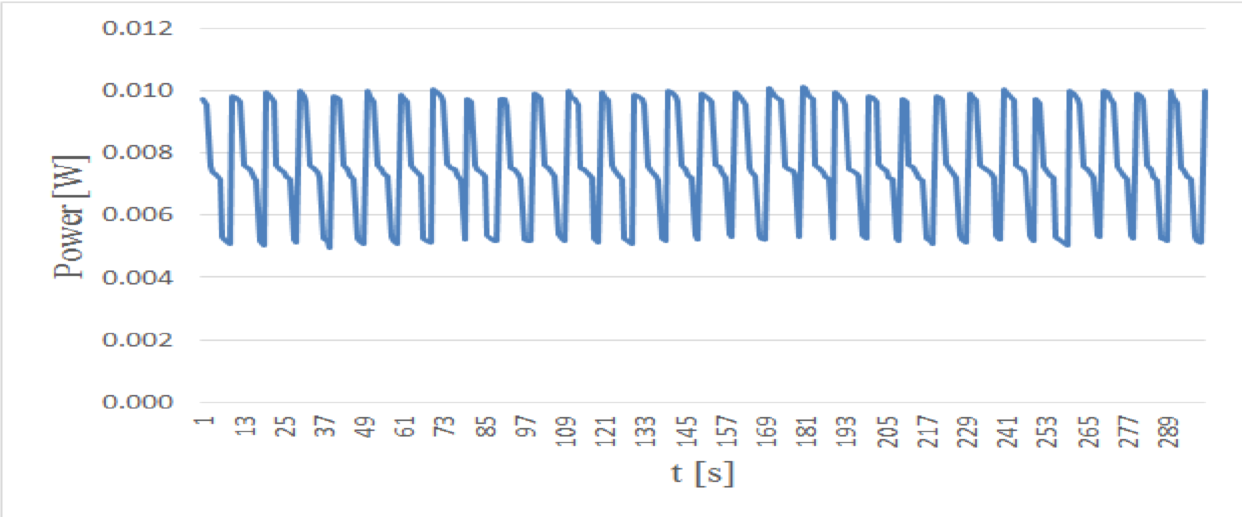

Figure-10. Measured power versus time in 7 centimeters wave height and period of 10 seconds.

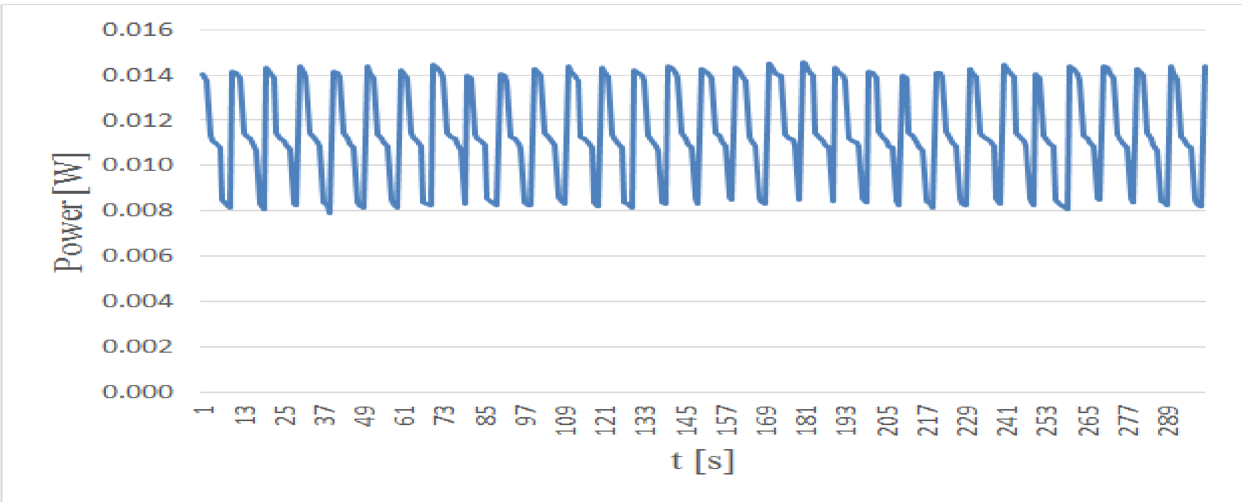

Figure-11. Measured power versus time in 9 centimeters wave height and period of 10 seconds.

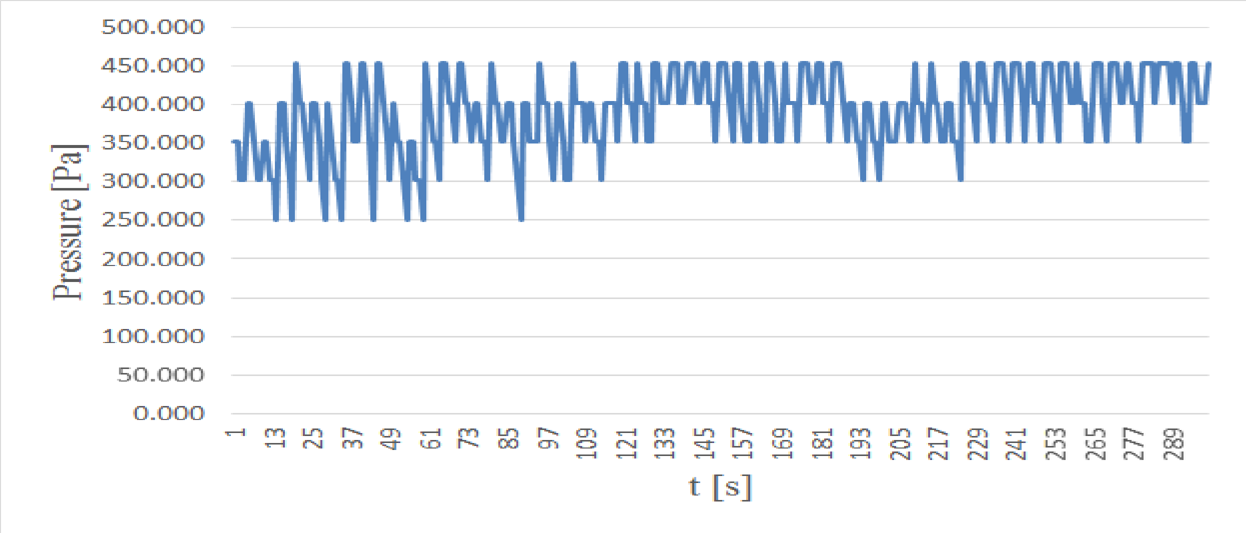

Figure-12. Measured pressure at the bottom versus time in 5. centimeters wave height and period of 5 seconds.

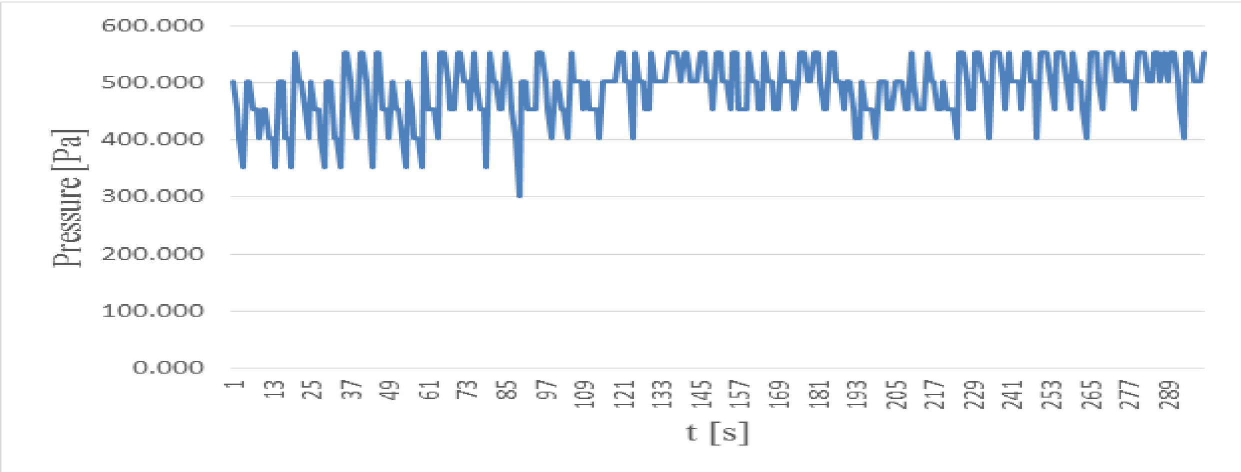

Figure-13. Measured pressure at the bottom versus time in 7 centimeters wave height and period of 5 seconds.

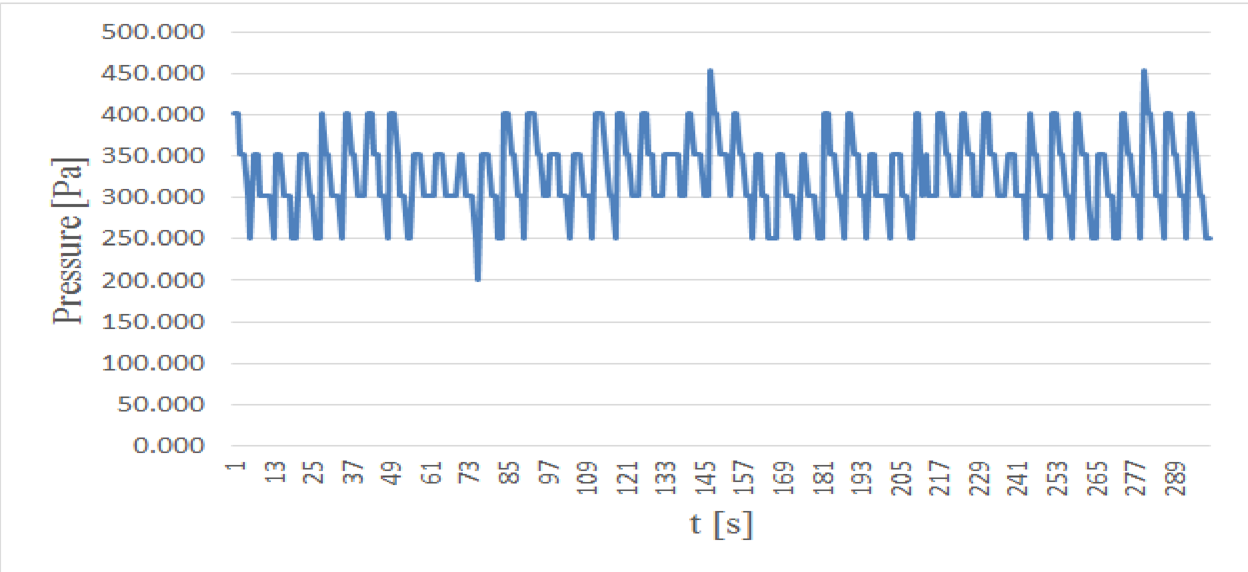

Figure-14. Measured pressure at the bottom versus time in 9 centimeters wave height and period of 5 seconds.

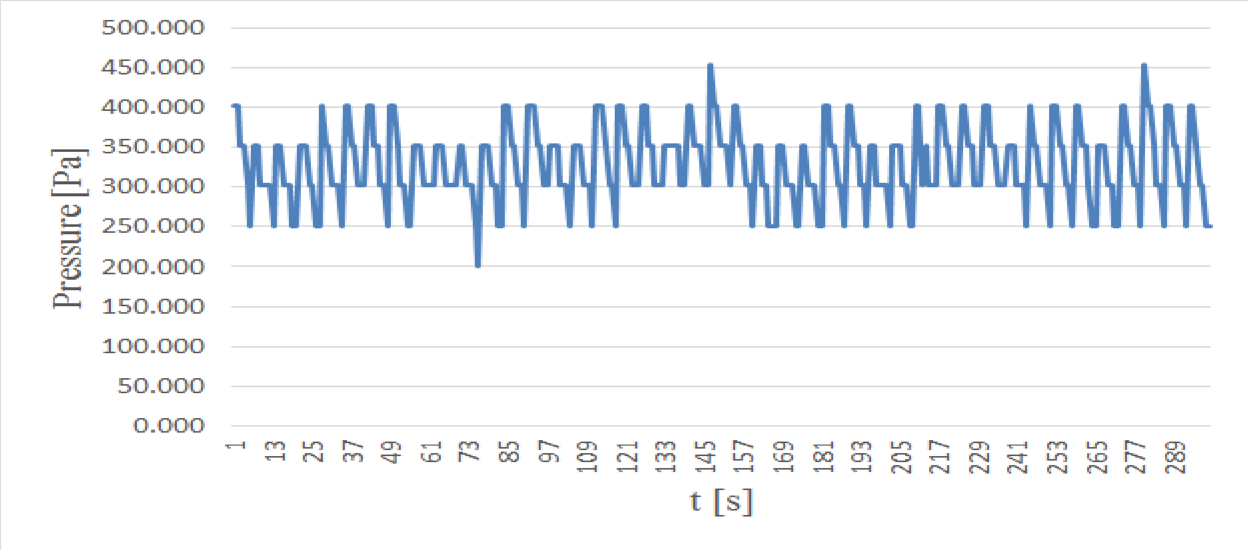

Figure-15. Measured pressure at the bottom versus time in 5 centimeters wave height and period of 7 seconds.

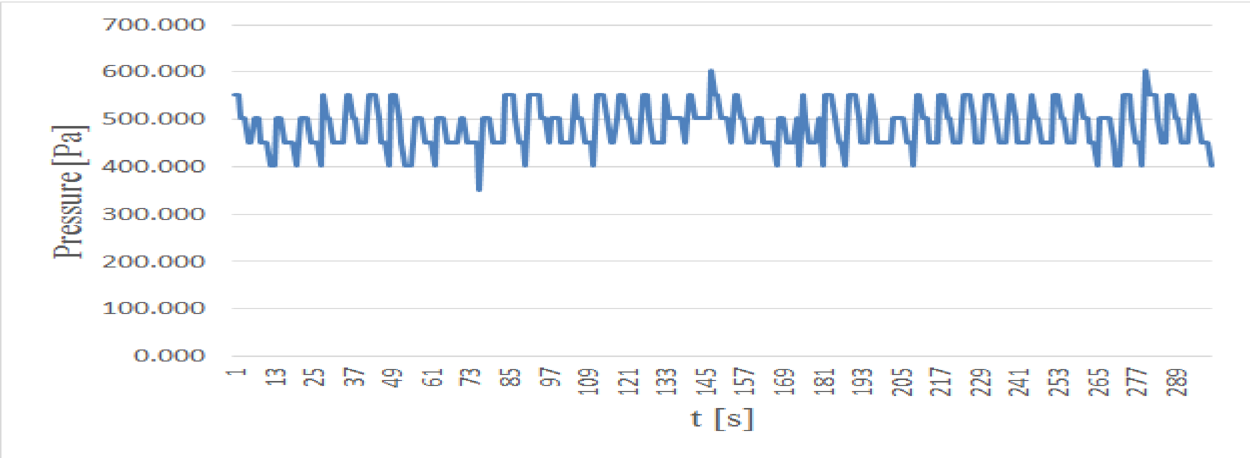

Figure-16. Measured pressure at the bottom versus time in 7 centimeters wave height and period of 7 seconds.

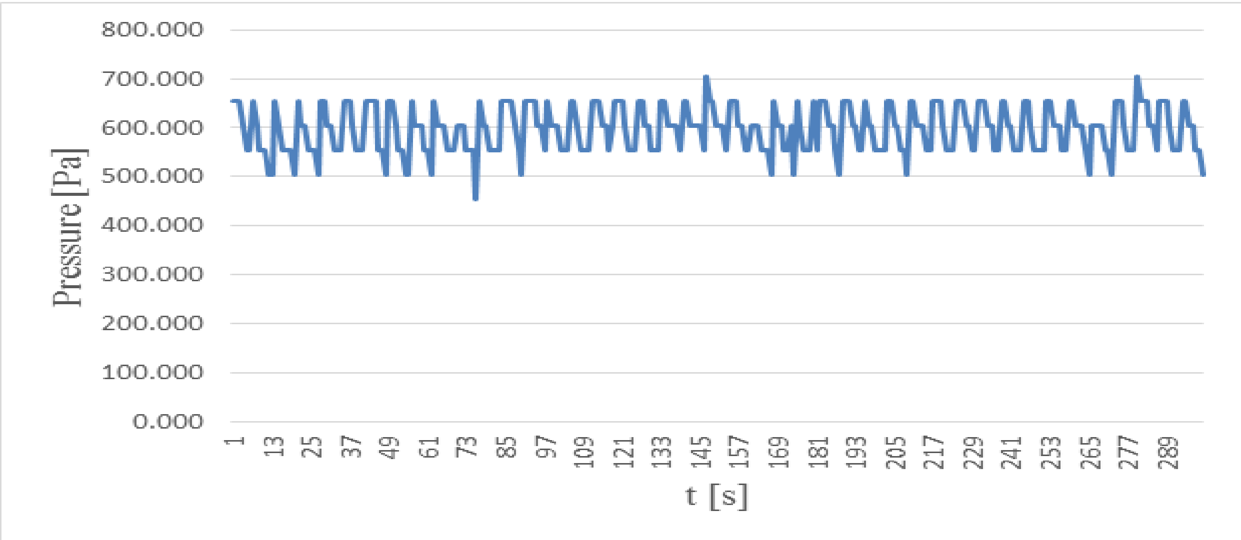

Figure-17. Measured pressure at the bottom versus time in 9 centimeters wave height and period of 7 seconds.

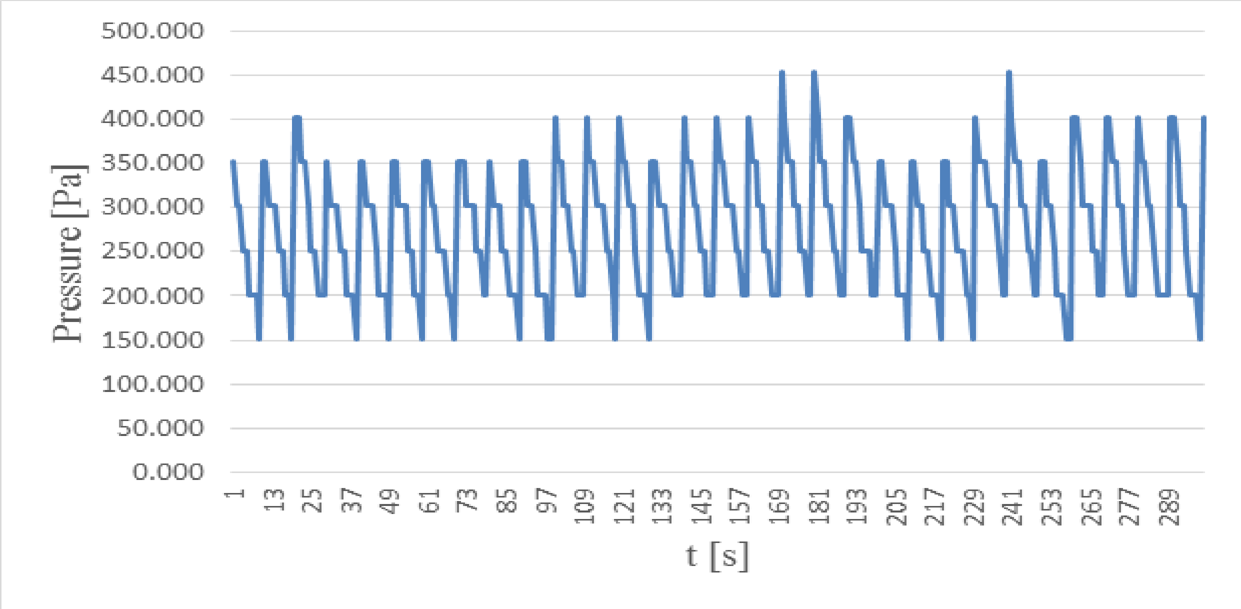

Figure-18. Measured pressure at the bottom versus time in 5 centimeters wave height and period of 10 seconds.

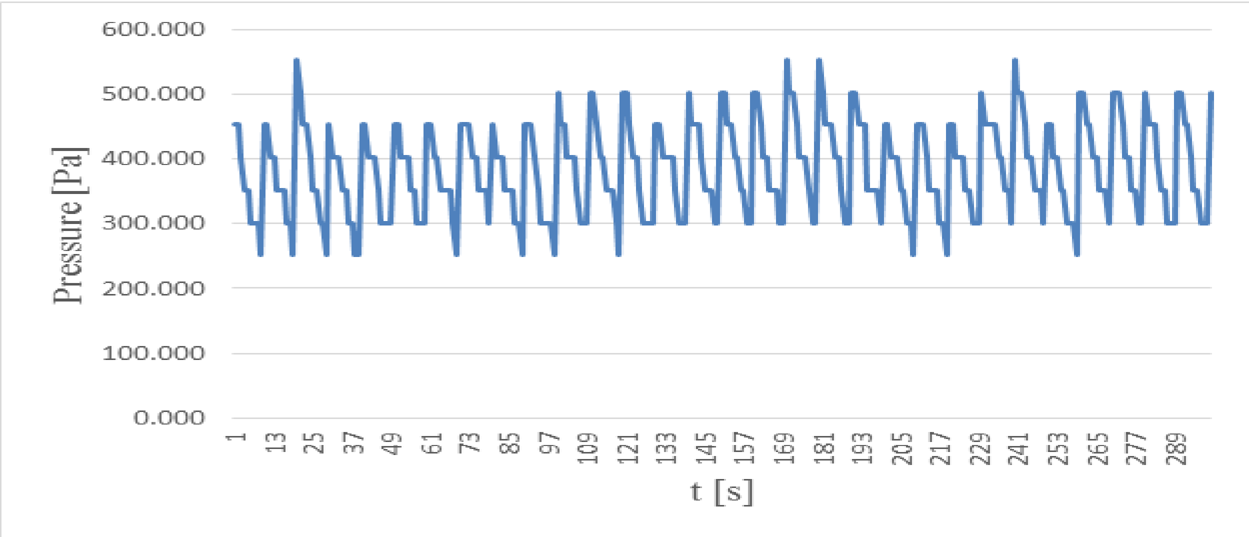

Figure-19. Measured pressure at the bottom versus time in 7 centimeters wave height and period of 10 seconds.

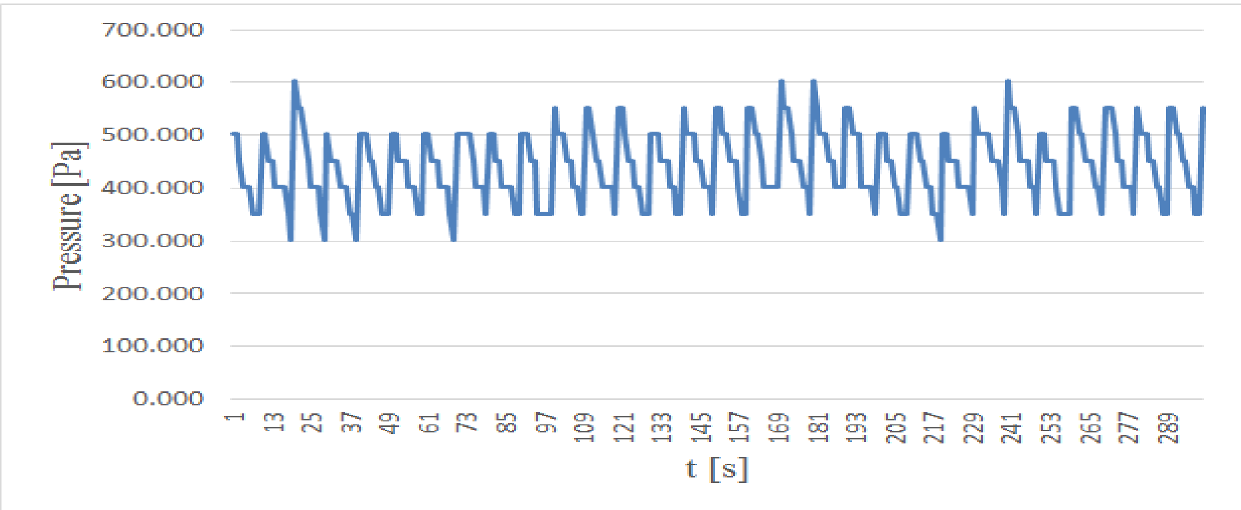

Figure-20. Measured pressure at the bottom versus time in 9 centimeters wave height and period of 10 seconds.

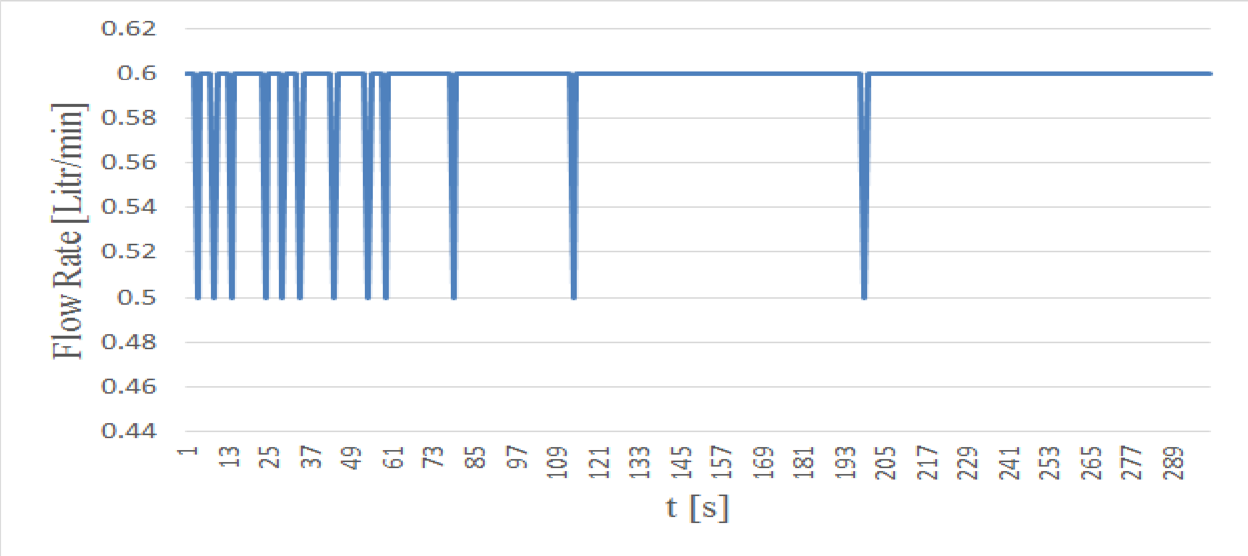

Figure-21. Measured flow rates versus time in 5. centimeters wave height and period of 5 seconds.

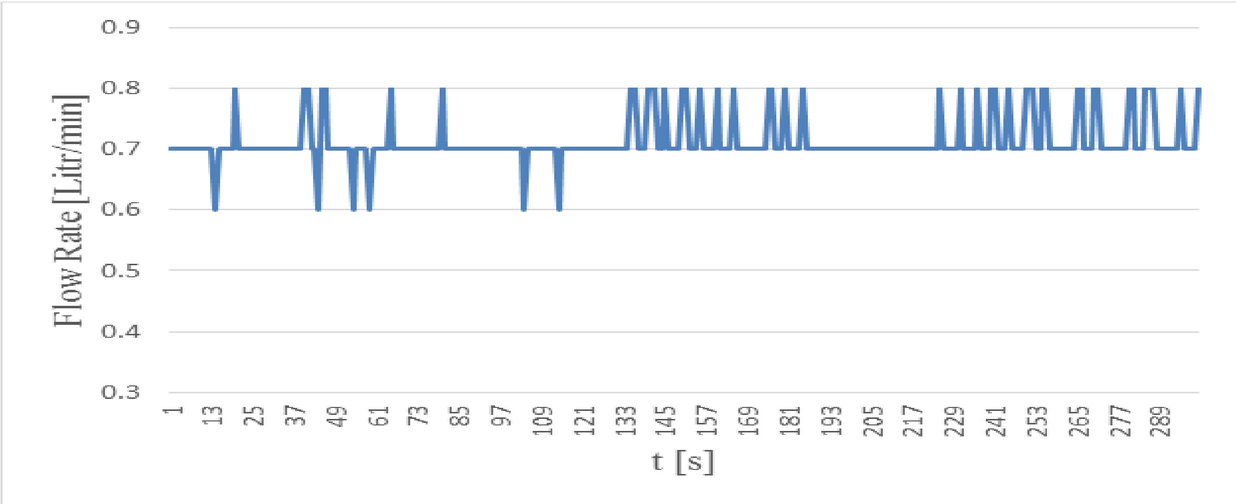

Figure-22. Measured flow rates versus time in 7 centimeters wave height and period of 5 seconds.

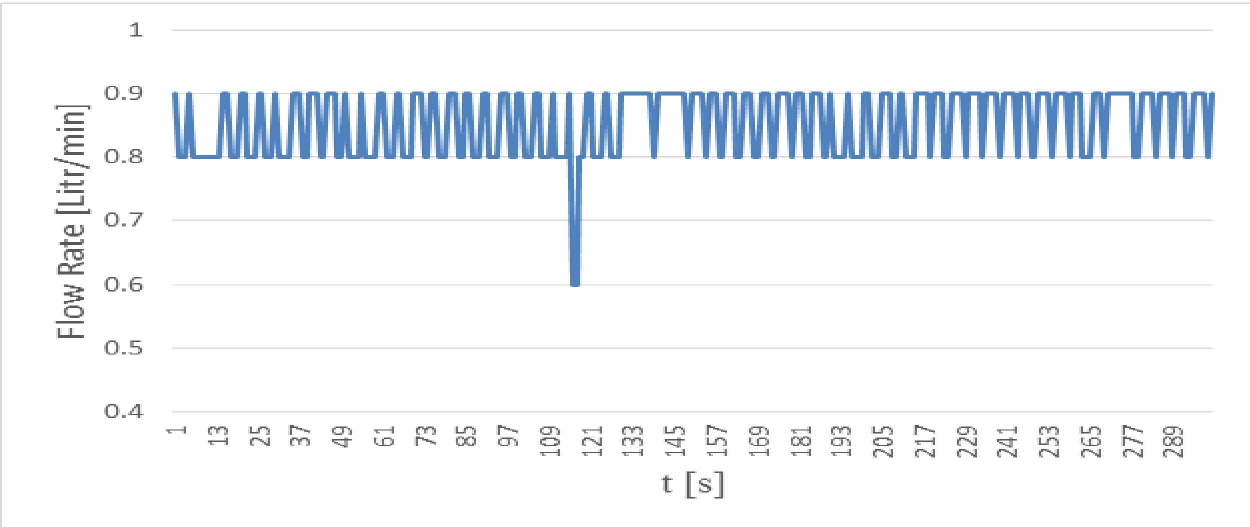

Figure-23. Measured flow rates versus time in 9 centimeters wave height and period of 5 seconds.

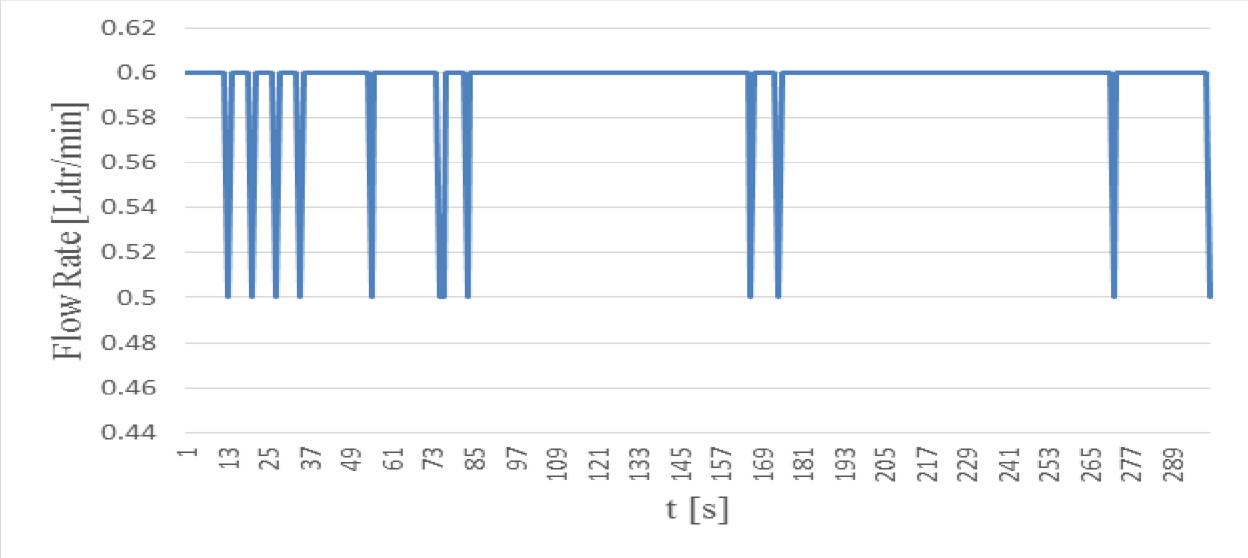

Figure-24. Measured flow rates versus time in 5 centimeters wave height and period of 7 seconds.

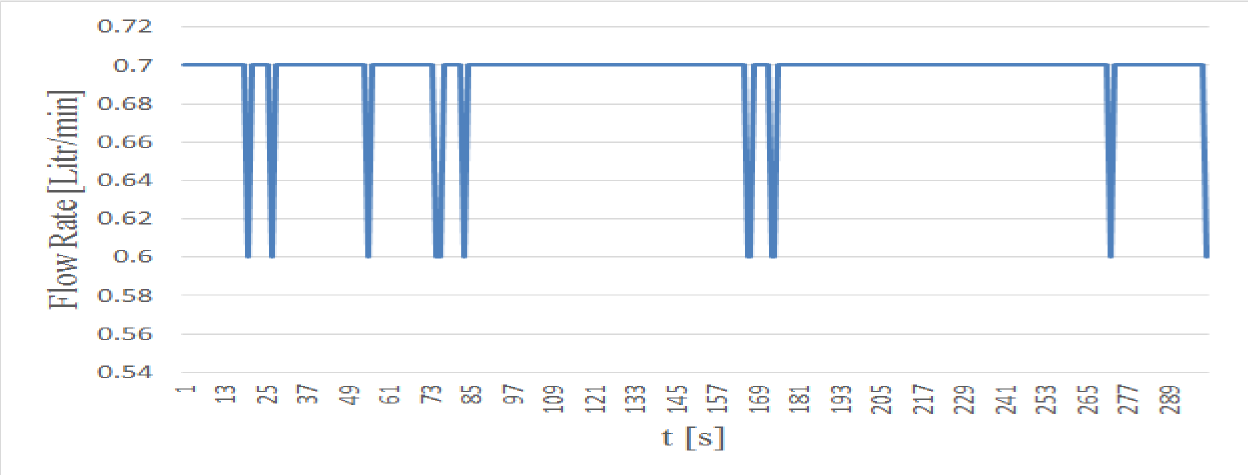

Figure-25. Measured flow rates versus time in 7 centimeters wave height and period of 7 seconds.

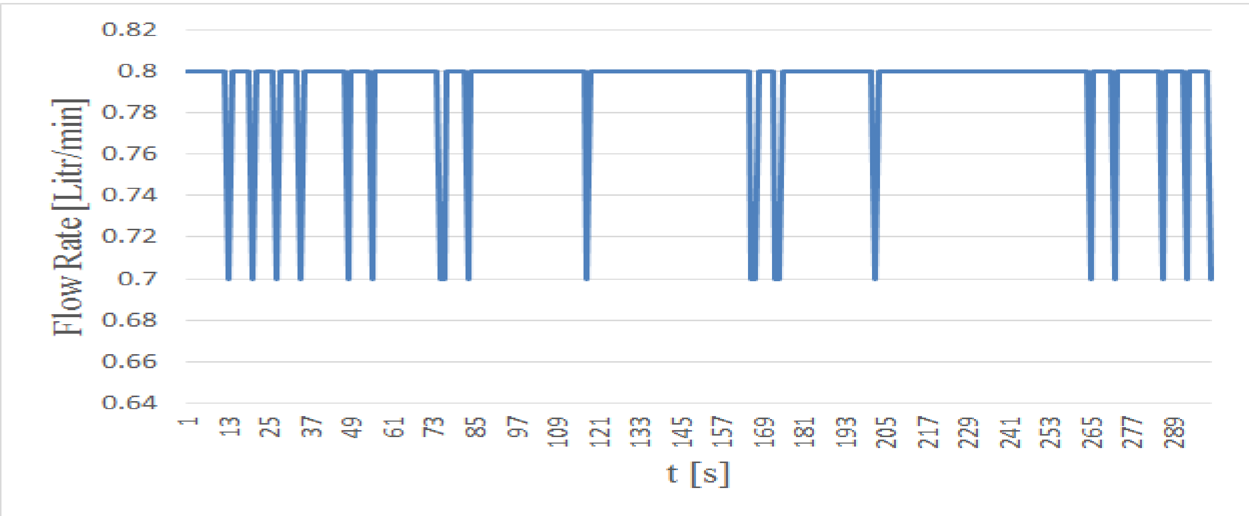

Figure-26. Measured flow rates versus time in 9 centimeters wave height and period of 7 seconds.

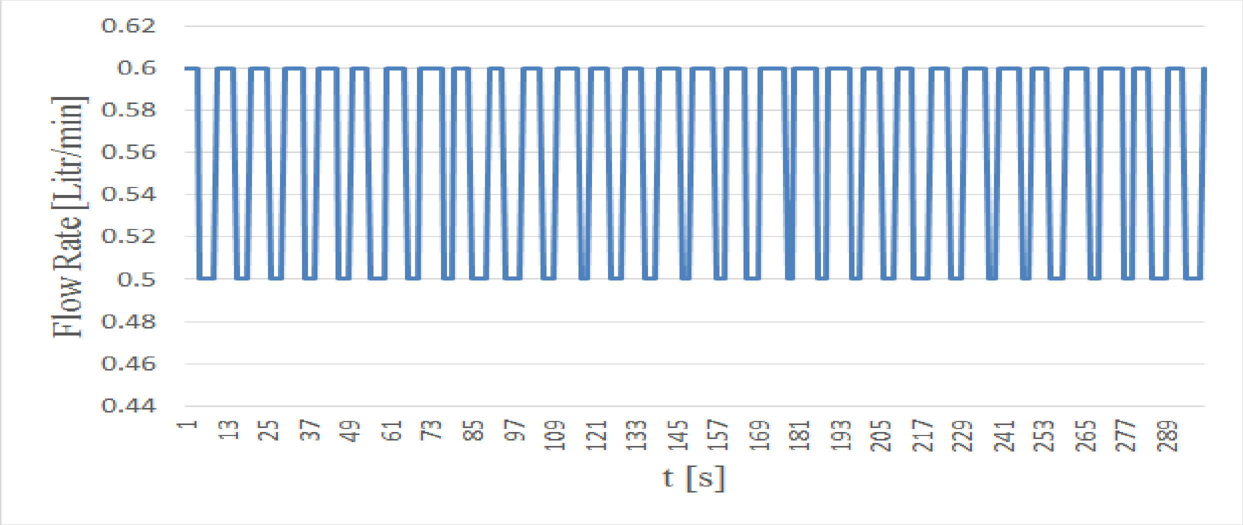

Figure-27. Measured flow rates versus time in 5 centimeters wave height and period of 10 seconds.

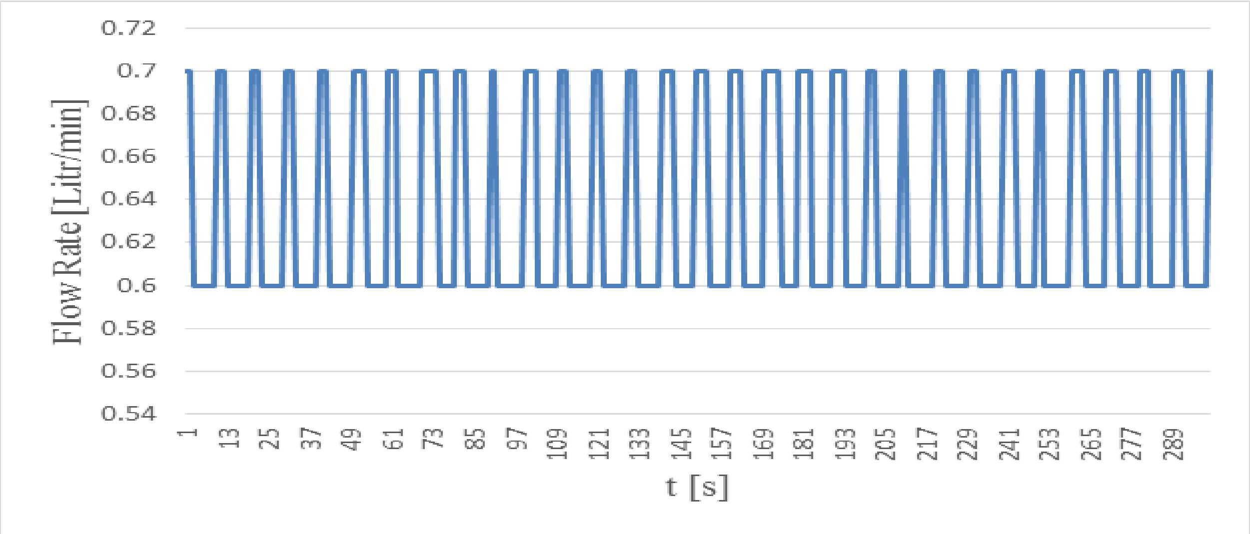

Figure-28. Measured flow rates versus time in 7 centimeters wave height and period of 10 seconds.

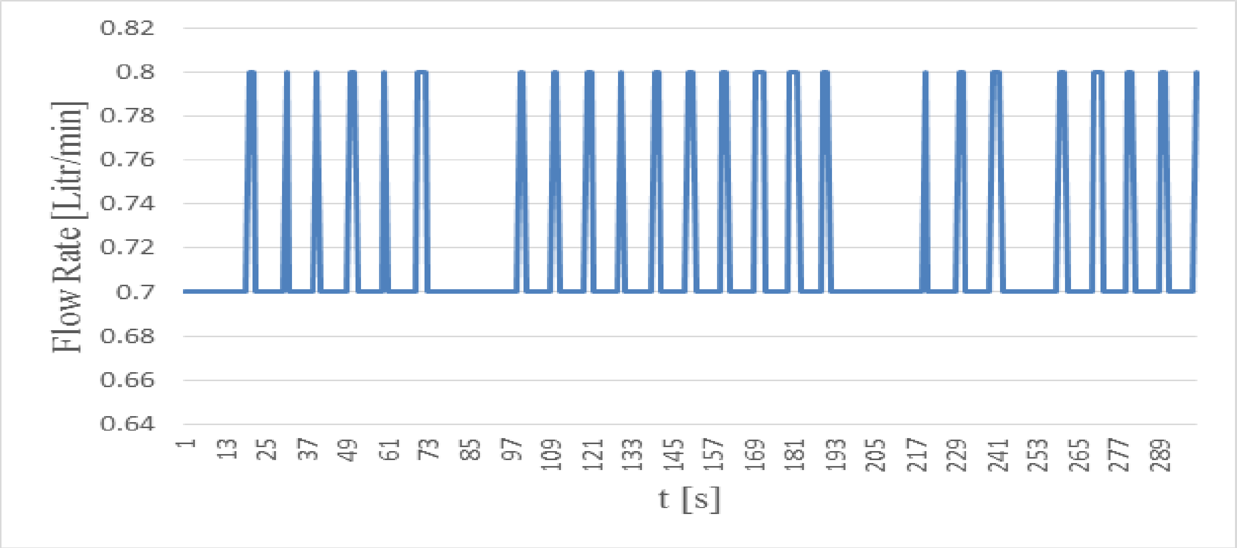

Figure-29. Measured flow rates versus time in 9 centimeters wave height and period of 10 seconds.

By studying the charts 4 and graphs 13 we see that efficiency in 5 centimeter wave height and wave period of 5 seconds to 5 centimeter in height and has 1% period decreased 7 seconds. Also, comparison charts 5 and 14 we see 1% efficiency. Consequently reducing the output voltage, power output is reduced. As a result, we find that by increasing the period of time when constant wave height is correlated with the voltage and power turbine and consequently reduce the power output of the turbine it.

In the following charts 5 and Chart 14, 21 1% efficiency tests on a wave with a height of 5 centimeter and a period of 5 seconds compared to the test in 7 centimeter wave height and period of 5 seconds. I see. Also, by comparing the graphs (6-9) and Chart (15-18) also saw an increase of one and a half percent efficiency due to the constant wave period and wave height are increased, so it could reasonably be concluded with a constant increase in wave height and period wave when the voltage is increased and consequently we are seeing an increase in power output device. This increase can be due to increased input current to the device is within a specified time, which increases the hydrostatic pressure of the tank floor and consequently increase the efficiency of the turbine.

By studying the different tests in terms of efficiency we see that efficiency is the wave height of 9 centimeter and a maximum time period of 5 seconds and increased hydrostatic pressure is directly related.

Maximum power output watts average power output of the device recorded the moment 025/0 023/0 watt, which is equal to the height of 09/0 and a wave machine test period is five seconds. According to the similarity relations dimension in the table (3-1) is the real model for the construction of the power plant with a capacity of 230 kW has built similarity 100.

4. CONCLUSION

In this paper, designing, building and testing a wave energy converter of Overtopping was studied and analyzed. Voltage output of the turbine, the power output of the turbine, the pressure at the bottom of the tank and the amount of current passing through the turbines in several waves with different heights and different time periods were presented.

As shown any change in terms of geometrical device can increase efficiency and effective. The turbine is designed specifically for this machine to get more power from the turbine can be studied and designed. The device is offered in terms of hydrodynamic waves are analyzed and movement Yau, Roll and Pitch are calculated. The following is suggested bracing system to the sea floor devices to be studied and simulated using the force to be calculated on the restraint system device structures.

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Competing Interests: The authors declare that they have no competing interests.
Contributors/Acknowledgement: Both authors contributed equally to the conception and design of the study.

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