WAVES ENERGY NEAR THE BAR OF RIO GRANDE'S HARBOR ENTRANCE

Gustavo Geraldes Pappen
Fundação Universidade Federal do Rio Grande – Av. Itália, km 8 – Rio Grande – RS
gpappen@hotmail.com

Jorge Alberto Almeida
Fundação Universidade Federal do Rio Grande – Av. Itália, km 8 – Rio Grande – RS
dfsjaa@furg.br

Abstract. *The waves energy can be pointed as a solution for the world energy generation problems. It consists of a concentrated form of solar energy, in form of kinetic and potential energy of the seawater, being a clean and renewable source, of great abundance in the nature. However, for efficient use is necessary to study the potential in each region. Our research objective is determine the waves energy potential near the bar of Rio Grande's harbor entrance, in south coast of Rio Grande do Sul, supplying data for a wider viability study of pilot plant implementation for waves energy use in this place. For so much, wave data were obtained starting from measurements accomplished by a directional wavemeter installed in 15 meters bathymetry, and coordinates 32°10'002" S and 51°58'913" W. Such data supply information as wave elevation and propagation direction. Starting from data evaluation of wave elevation, was determined the wave profile and calculated the wave power in the place.*

Keywords*:* waves energy, wavemeter

1. Introduction

The world problem solution of electric power generation will should come from the oceans, once these possess a great and unexplored energy potential. One way to obtain energy starting from the oceans is to use the wave oscillatory movement, being this renewable source of energy, of great abundance and no cause of serious environmental impacts.

The waves energy is a concentrated form of solar energy, once the winds generated by temperature differences in the atmosphere transfer his energy for the ocean surface. The largest energies are found in deep waters, when these waves approach the coast happens friction between the wave and the sea bottom.

In the last thirty years numerous technologies have been studied, among which the Oscillatory Water Column (OWC), Pelamis, Wave Dragon and Archimedes Wave Swing (AWS). The Oscillatory Water Column plant constitutes the process more investigated, being usually a coastal system, although it can also be installed in high sea. The other devices are offshore systems, exploring regimes of larger potency of the waves, but needing anchorage and long underwater electric cables to transmit the generated energy until the coast.

For the use of this energy, it is necessary the study of potential in each place. Our research objective is determine the waves energy potential near the bar of Rio Grande's harbor entrance, in south coast of Rio Grande do Sul, in order to take place a wider viability study for implantation of a waves energy pilot plant in this place.

2. Data Acquisition

The data used for calculate the waves energy potential were obtained through measurements accomplished by a directional wavemeter, that consists of an instrument for evaluate the undulatory behavior in the place where is installed.

Such instrument was anchored by Instituto Nacional de Pesquisas Hidroviárias (INPH) in 1996, in a partnership with the Department of Physics of Fundação Universidade Federal do Rio Grande (FURG), having objective of accomplishing a measurement of the undulatory behavior near the bar of Rio Grande's harbor entrance.

In that time, the study sought to verify the bar recovery project, whose project was based in an old measurement of undulatory behavior accomplished in 1963.

The wavemeter was installed in 15 meters bathymetry, in the coordinates 32°10'002" S and 51°58'913" W, in front the east bar, as show in Fig. 1.

The wavemeter data transmission was accomplished through radio waves with frequency between 27 and 40 MHz. These data were transmitted to a receiving station, in the Department of Ports of the Ministry of Transports, located in Quinta Seção da Barra, municipal district of Rio Grande and weekly transferred, for the facilities of Physics Department in the Campus Carreiros of Fundação Universidade Federal do Rio Grande (FURG).

The equipment was programmed to acquire data in a period that can vary depending on the sea agitation degree. Case the significant height value of waves were smaller than two meters, the data acquisition happens in three hours time interval. Otherwise, as during storms, the acquisition will be in way practically continuous along the time, corresponding the period among acquisitions at half hour.

Figure 1-Location of the directional wavemeter

The wavemeter stores information in three different type files, being a type regarding the data, one regarding the spectral response generated by the wavemeter and the last regarding the statistical analysis of the data.

The analyzed data are regarding the year of 1998, once this corresponds to the longest measuring period, although it has had three interruptions in measuring during elapsing of the year.

The first of them includes almost whole month of January of 98, and the measurements analyzed began only in the end of January, after a long idle period caused by the breaking of the wavemeter anchor during a storm, in August of the previous year.

The second interruption happened when, on May 17, an oceanic front with waves of up to 7,5m it caused a new breaking of wavemeter cables. After a small pause, on June 14 the system was reestablished. Already the third gap in the measurements occur in a short period, of November 12 to December 03.

As the interruptions represent a short period, in comparison with the whole year, these were despised during the data analysis.

3. Data Analysis

Only the original data supplied by the wavemeter was used in this study. The data files supply, in text form, instrument status values, elevation (in centimeters) relative to the average sea level, wave propagation direction northbound and wave propagation direction eastbound, disposed in four columns.

Only the determination of medium heights and periods of waves has interest in study of available energy potential. The wave energy are not supplied directly by the wavemeter, but is obtained by the original data analyses.

In order to process the great amount of information, it was necessary the elaboration of a computational algorithm capable to execute several tasks. The algorithm consists of the following steps:

1. Read the files corresponding to the original data.
2. Determine the wave profile starting from data supplied in second column.
3. Identify the maximum and minimum oscillation picks, with their respective times of reading.
4. Calculate the average height and the average period of each data group.
5. Record the result in a new file.
6. Calculate the average height and average period, for all data groups in the month, taking into account the acquisition time and the data number.
7. Calculate the total energy potential.
8. Record the final result in a new file.

The programming language used was Pascal in the development of such program. It was very applicable and easy to programming, since was not need to elaborate a graphic user interface. Only the procedures described above were built, and they are executed in sequence and automatic way, without need the user's commands.

According to Dean and Dalrymple (1991), the total medium energy per unit length of a wave having height H and length L is given for:

$$E = \frac{1}{8}\rho g H^2 L \tag{1}$$

However, the length L can be expressed in function of the period, being, in deep waters, given for:

$$L = \frac{gT^2}{2\pi} \tag{2}$$

Substituting the equation 1 in 2 and dividing for the period to obtain the wave potency, result in equation 3:

$$P = \frac{\rho g^2 T H^2}{16\pi} \tag{3}$$

Where P is the wave potency per unit of length of crest in W/m, g, the gravity acceleration in m/s², T, is the wave period in s and H, is the height in m.

This equation is valid for a deterministic model, considering linear waves of small widths and formed out analysis area. Besides, the measurements place was adopted as consisting of deep waters, in that the wave doesn't interact physically with the sea bottom.

Starting from the original data and executing a single time the program for each month of analysis, was obtained successive named files corresponding to the respective month and containing the significant average height of waves, in centimeters, the average period in seconds and the correspondent available energy per wave crest unit length, in kW/m.

Such values, was analyzed statistical in order to determine the curves of undulatory behavior along the analyzed year.

4. Results

One in the most important ways of presentation the wave data consists of representing the parameters evolution graphically for each month. We can, through a simple visualization of interest period, evaluate the behavior of important parameters as the medium height of waves, medium period and potency per length unit.

After original data analysis regarding each month, as well as the statistical analysis, it can be verified that the annual medium period is 6,88s. The variation curve along the year is shown in the Figure 2.

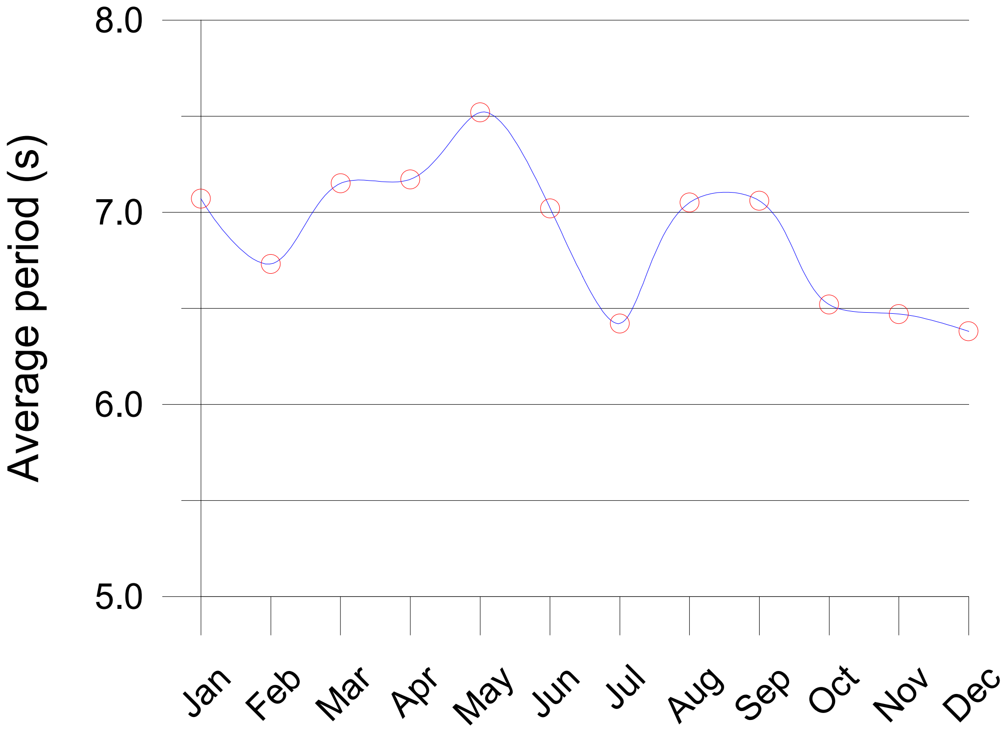

Figure 2- Variation of monthly medium period of waves along the year 1998

The medium significant height is equal to 76,06cm. Figure 3 show medium significant height behavior of waves along the year of 1998.

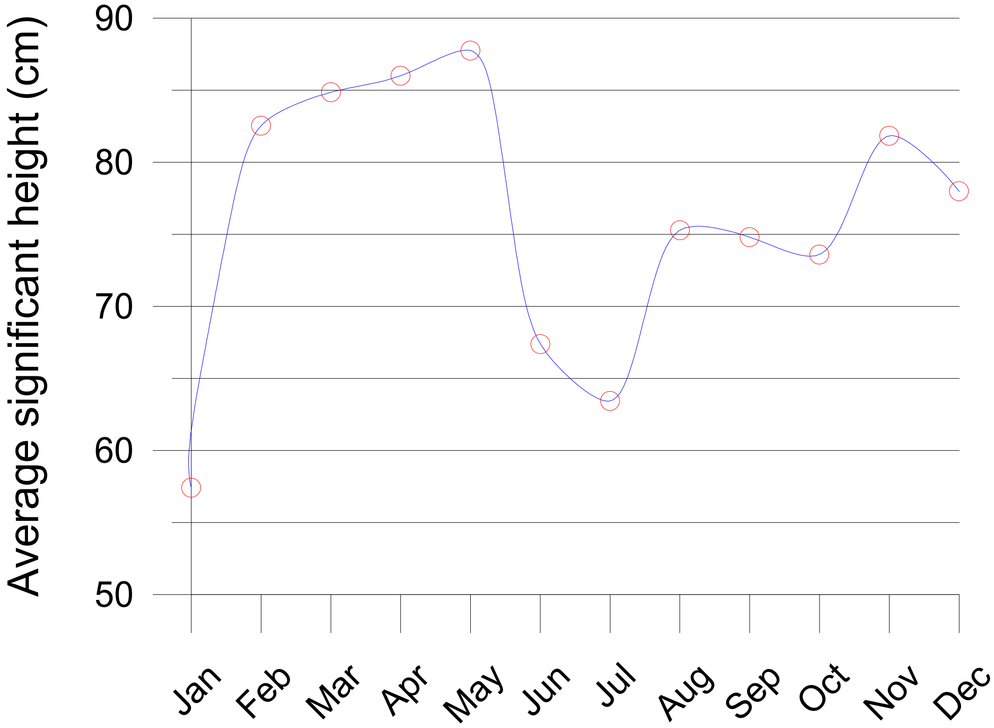

Figure 3- Variation of medium significant height monthly of waves along the year 1998

The medium potency of waves along the months and regarding the height values and period is shown in Figure 4. The annual medium potency is equal to 7,75kW per meter in wave crest length.

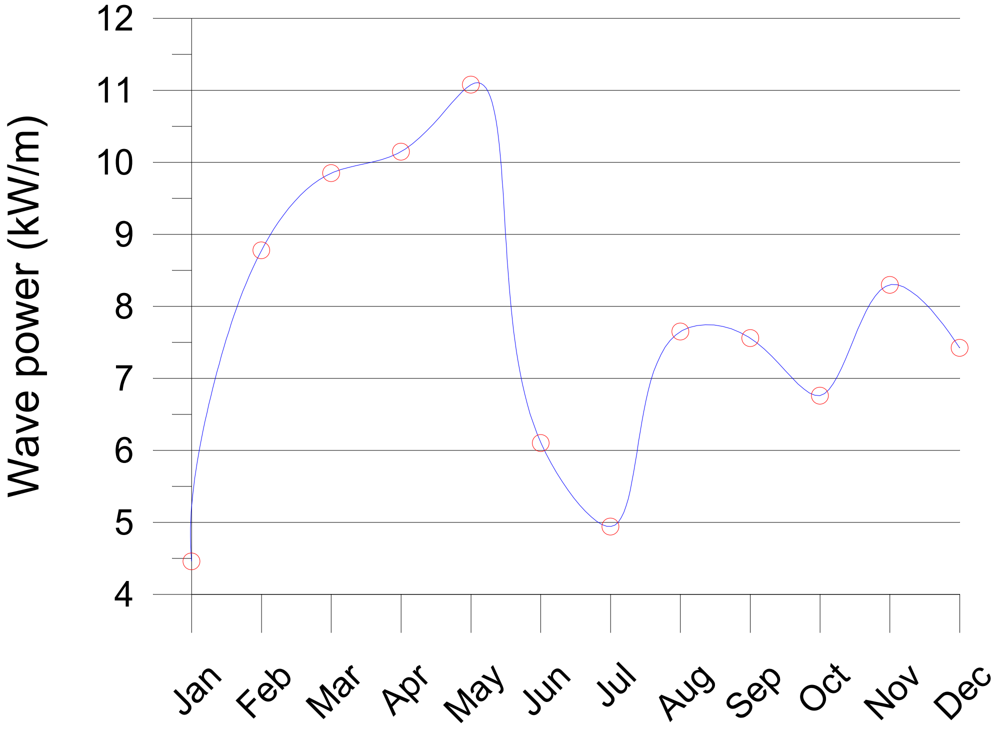

Figure 4- Monthly medium Potency of waves along the year of 1998

These results were obtained of a totality of almost 3000 files, each one containing 1200 data approximately and it can be considered that it represent the tendency in the form of occurrence of analyzed parameters.

Thorpe (1998) foresaw the distribution of waves power (in kW/m) in far places of the coast, and plot the results in a world map. This map is shown in Figure 5 and we observed that the measured value in Rio Grande corresponds to approximately 40% of the value foreseen for the area.

5. Conclusion

It is important that it is had in mind that the amount of information accumulated is not still enough for accurate determination of available energy and his variation along the year, because we analyze data regarding only one year (1998).

However, such study serves as reference for new studies, or still as incentive to continue the data acquisition in the place and to encourage a project for build a pilot plant of waves energy.

The values of available medium potency per meter of wave crest correspond to 40% of the values obtained by Thorpe, what comes to reinforce the need of a wider study about the theme.

The observation of wave height value and medium period reveals coherence initially in the correlation with characteristic parameters of waves, what gives trust in the obtained results.

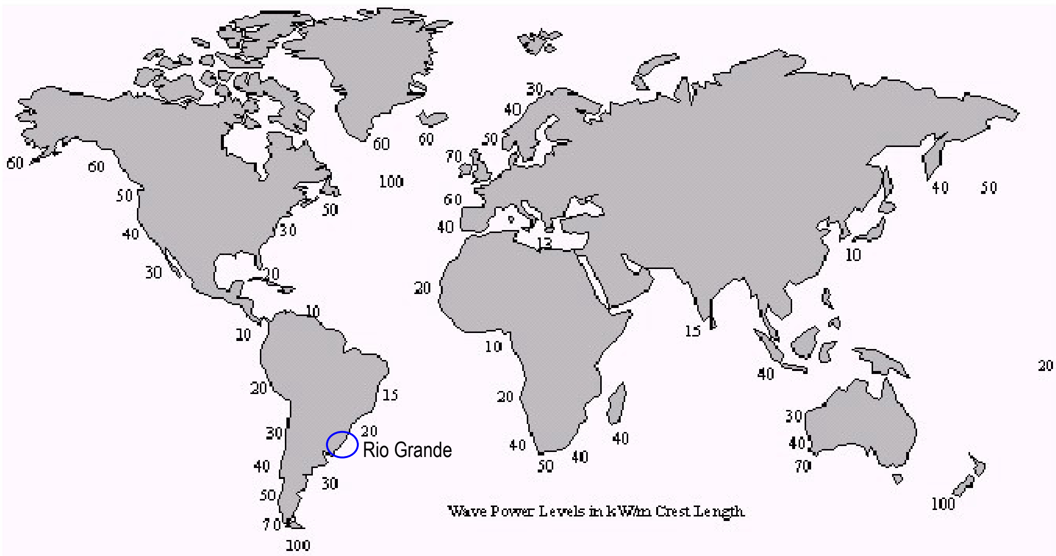

Figure 5 - Distribution of wave power (Thorpe, 1998)

It can be observed, that the picks of maxim energy in the analyzed period correspond exactly at the months, which there was interruption in the measurements, due to the passage of oceanic fronts. The occurrence of oceanic fronts and storms elevate the values of wave height in fact and associate to this an error, characterized by the fact of the measurements interruptions cause a decrease in the number of analyzed data. In these months the calculated averages show tendentious results, larger than the real, same when those averages take into account the period of data acquisition.

The amount of available information can be considered insufficient for a reliable study, being necessary a monitoring during a larger time interval and without interruptions. This study is important due to promising future in the use of waves energy, considering the world energy need associated to the characteristic advantages of that energy type.

6. References

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7. Responsibility notice

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