Evaluation of Wave Energy Potentials in Chahbahar port using two methods of water-wind model and wave measurements

Ahmad Sedaghat[1], Ahmad Reza Zamani[2]

[1]Department of Mechanical Engineering, Isfahan University of Technology, Isfahan 84156-83111, I.R. of Iran (sedaghat@cc.iut.ac.ir)
[2]Subsea R & D Center, Isfahan University of Technology, Isfahan 84156-83111, I.R. of Iran (arzamani@cc.iut.ac.ir)

Abstract

Renewable energies such as wave energy, despite rapid technological progress and potentials in Iranian waters, are yet require careful feasibility studies. Recent developments of marine energy in the world can manifest itself for implementing marine energy absorber devices in Iran. In this paper, the average annual wave power of Chabahar port is determined using two approaches. A wave-wind model and three months experimental data are used for comparison. The wave-wind model predicts the annual wave power 4.746 kW/m^2 (approximate method) and 8.621 kW/m^2 (accurate method), which are higher than the measurements. This suggests that further improvements in modeling and more measurements should be obtained for correct evaluation of Iranian marine energy.

Key Words: Wave Energy potential, Water-wind model, Chabahar Port.

Introduction

The idea of using sea waves is not new and it was first introduced by Jirard and Son (in Leishman and Scobie (1976)) as a patent. With increasing oil prices in 1973, the stronger attention was again directed towards wave energy. Several research programs were conducted with supports of the governments and private companies such as Denmark, Ireland, Norway, Portugal, Sweden, and England. In 1986, the European unions were added more supports by observing developments in this field. In this time, two essential studies for evaluating wave energy potentials were established: first, preparation of ATLAS of wave energy sources (Fig. 1), in Europe (1996), second, evaluation of streams and sea waves (1996).

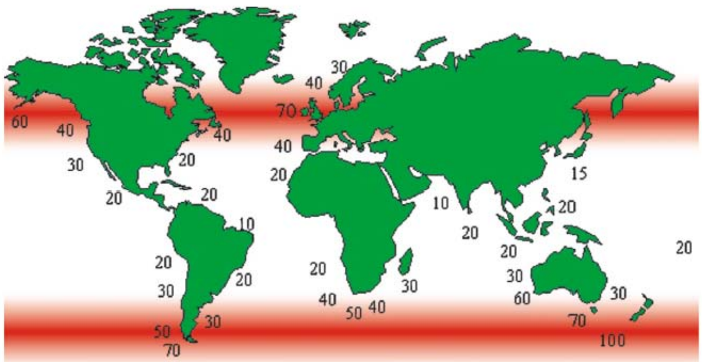

Fig. 1) Distribution of the world wave energy potential (kW/m)

Classification of Different Wave Energy Extractor Devices

Figure 2 shows different methods for extracting wave energy based on the type of motion that is absorbed by the system.

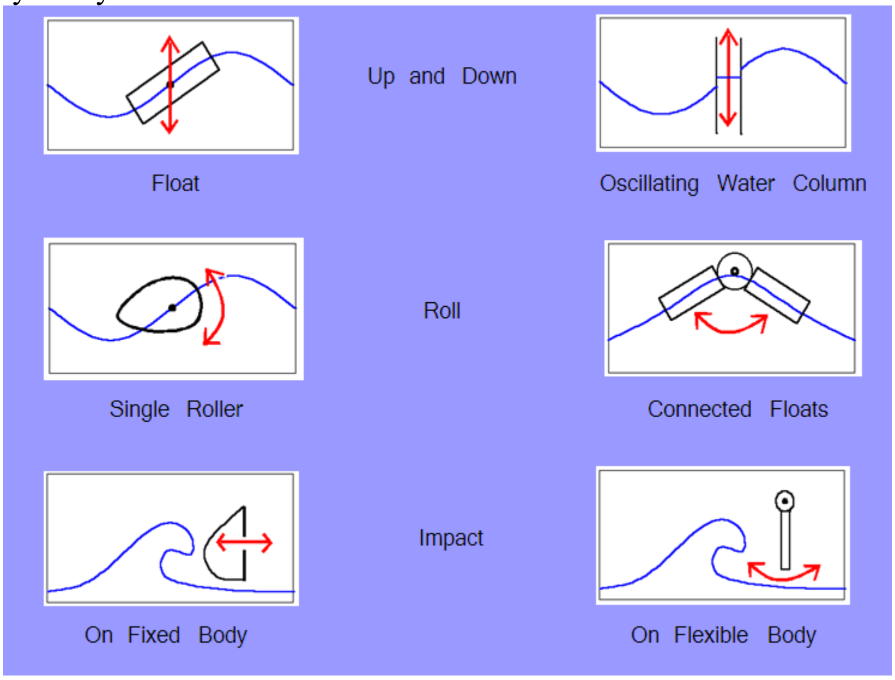

Fig. 2) Classification of different wave energy convertors based on the type of motion of the wave energy absorber device

Wave Energy Potential in Chahbahr Port

With rapid seasonal and annual changes, evaluation of sources of wave energy should be based on long term data. The usually suggested period of time is equals to 10 years. However, in this paper, we have used the information and data from water-wind models for a period of 5 years (1998 to 2002) [2] and also the experimental data for 3 months (the first three months in 2010) for wave energy potential in Chahbahar.

As shown in Figs. (3) to (8), for obtaining the most probable effective height and wave period, the 2D and 3D histograms are shown for water-wind and wave data.

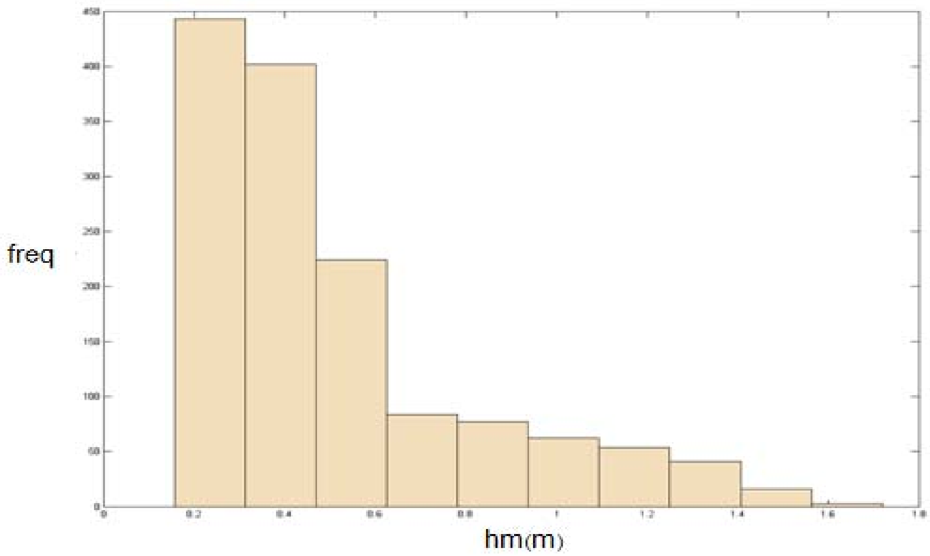

Fig. 3) 2D Histogram of the effective wave height for 3 months wave data in Chahbahar port

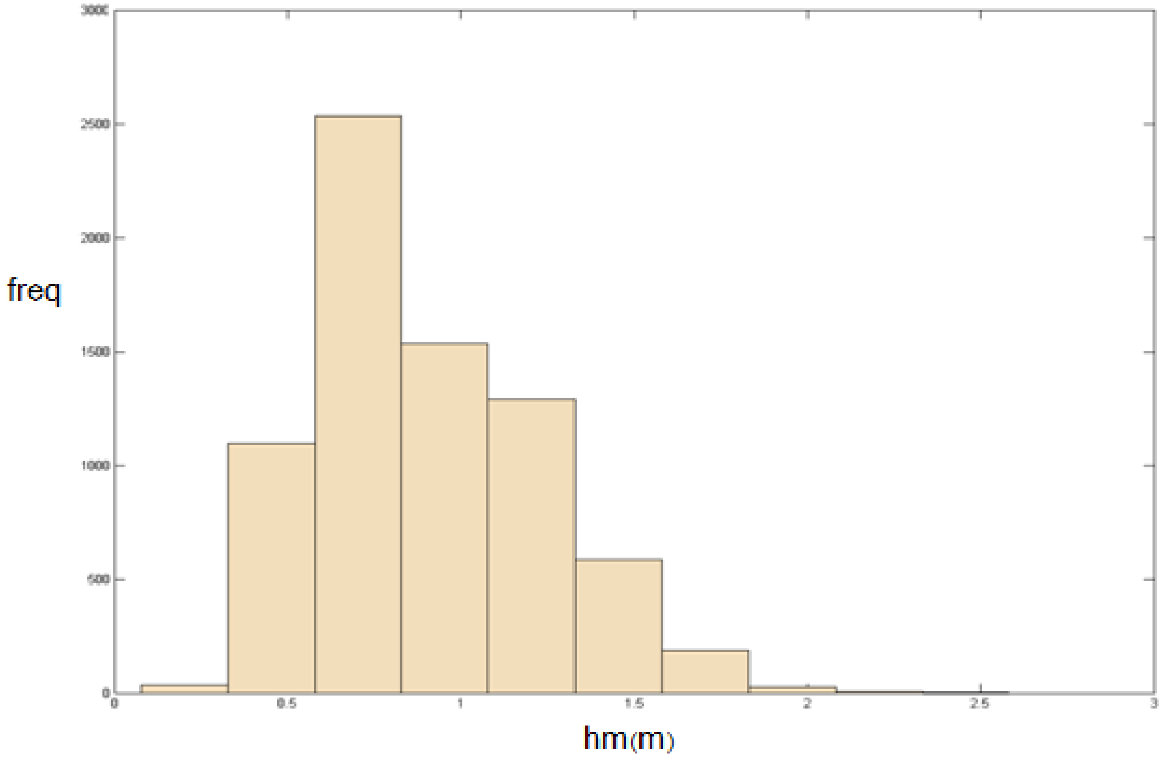

Fig. 4) 2D Histogram of the effective wave height for 5 years data of water-wind model in Chahbahar port

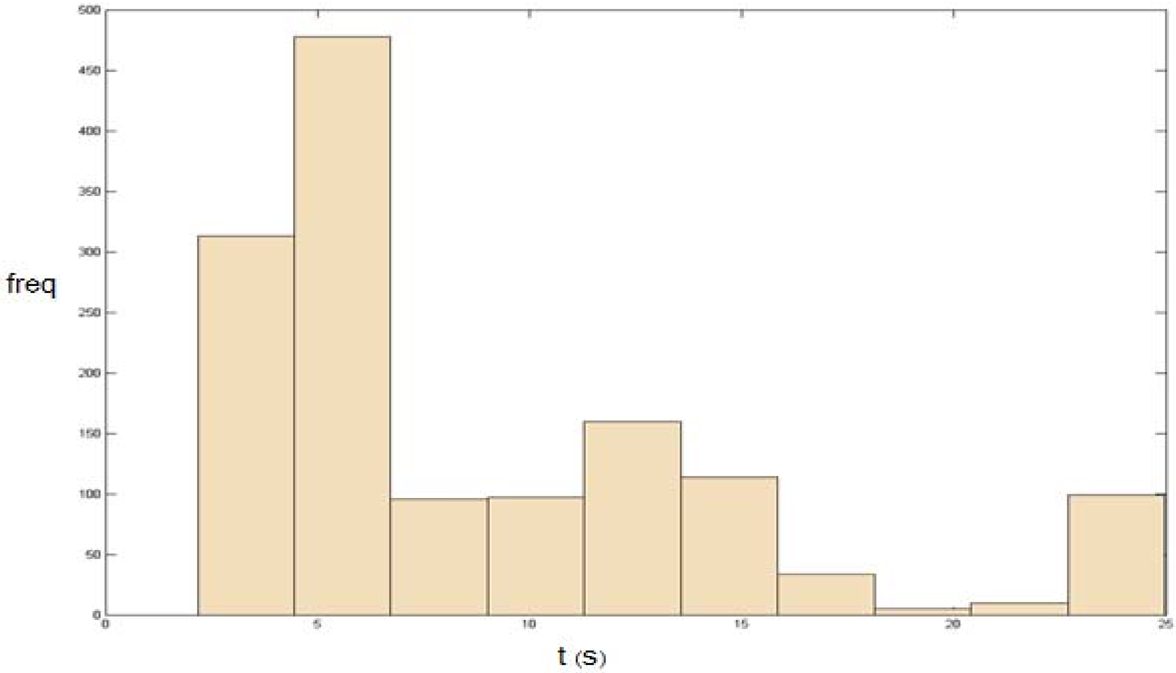

Fig. 5) 2D Histogram of the wave period for 3 months wave data in Chahbahar port

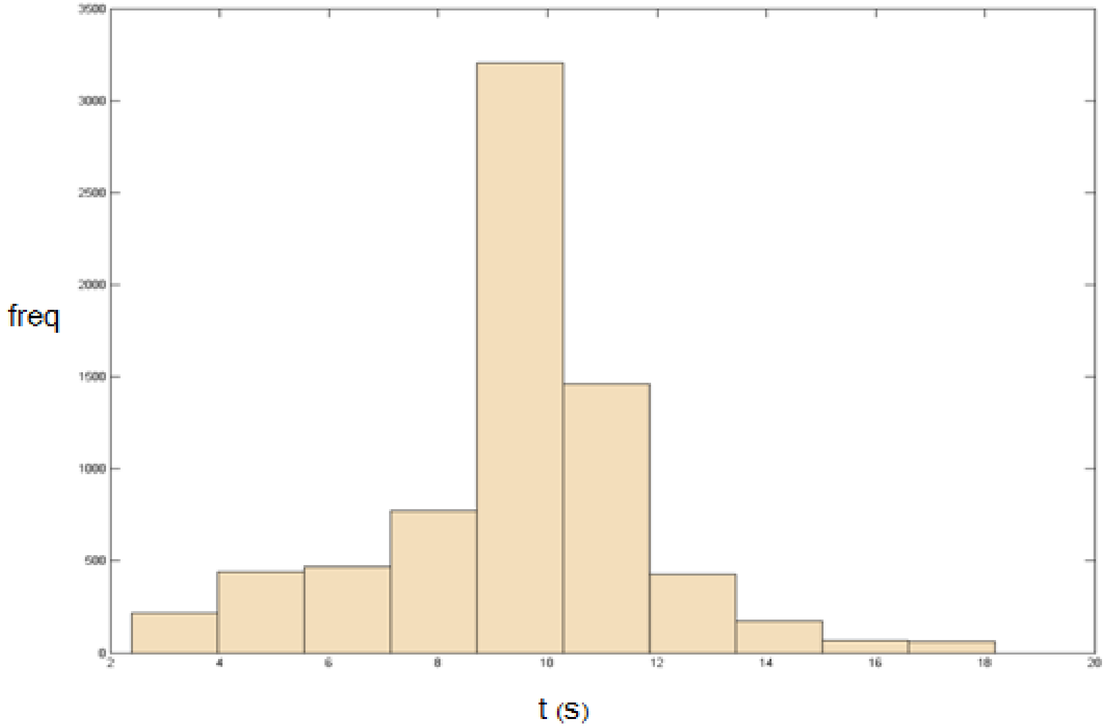

Fig. 6) 2D Histogram of the wave period for 5 years data of water-wind model in Chahbahar port

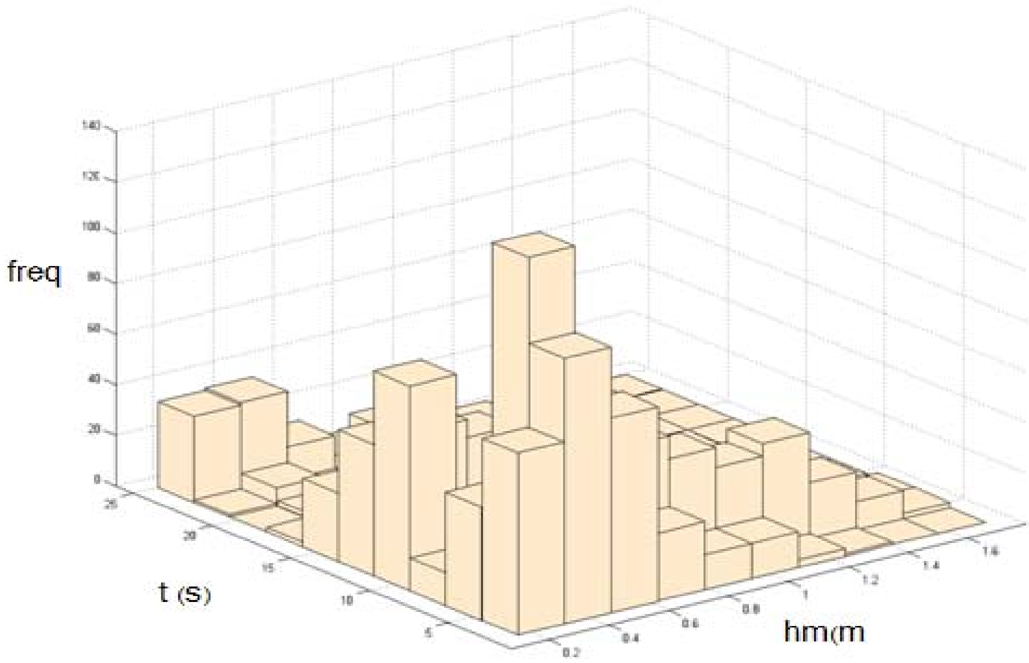

Fig. 7) 3D Histogram of the wave effective height and wave period for 3 months wave model in Chahbahar port

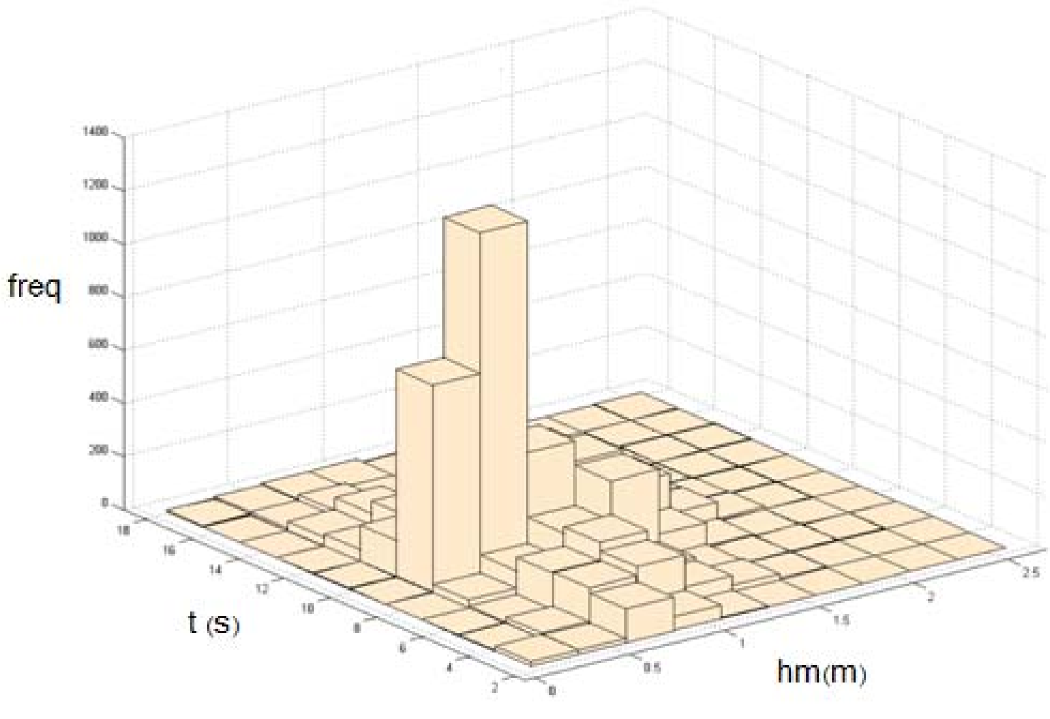

Fig. 7) 3D Histogram of the wave effective height and wave period for 5 years data of water-wind model in Chahbahar port

Analysis of Wave Power using Two Accurate and Approximate Methods
1. Accurate Method

In accurate method, the wave length in deep water is calculated from [3]

$$L_0 = \frac{gT^2}{2\pi} \quad [m] \tag{1}$$

And then the wave length in any depth is calculated from

$$L = L_0 \tanh\left(\frac{2\pi d}{L}\right) \quad [m] \tag{2}$$

From the other way, the available energy in waves is calculated from

$$E_{total} = \frac{1}{8}\rho g h^2 \quad [\frac{J}{m^2}] \tag{3}$$

Finally, the wave power is calculated from energy relation as

$$P_{wave} = E_{total} n c \quad [\frac{kW}{m}] \tag{4}$$

In which

$$n = \frac{1}{2}\left(1 + \frac{2kd}{\sinh(2kd)}\right) \tag{5}$$

$$c = \sqrt{\frac{g}{k}\tanh(kd)}$$

$$k = \frac{2\pi}{L}$$

2. Approximate Method

In the approximate method, the relation for deep water waves is simplified as [4]:

$$P = \frac{\rho g^2 h^2 T}{32\pi} \approx h^2 T \tag{6}$$

Then with the definition of the wave effective height and the effective period, the power is calculated approximately as

$$P = 0.49 h_s^2 T_s \tag{7}$$

Results of Calculating Wave Power using Accurate Method

The results from calculations on the average effective height, the average temporal period, and the average power using the accurate method is listed in tables (1) and (2). Only the average power is presented for comparison in these tables using the approximate method.

Table 1) Comparison of the average annual power in Chahbahar port during 1998 to 2002 for the 5 years water-wind model

Time	Average effective height of wave (m)	Average temporal period (s)	The average power with accurate method (kW/m)	The average power with approximate method (kW/m)
1998	0.876	9.432	8.389	4.604
1999	0.972	9.135	10.041	5.551

2000	0.919	9.526	8.944	4.887
2001	0.845	9.288	7.534	4.111
2002	0.872	9.574	8.197	4.579
The average of 5 years	0.897	9.391	8.621	4.746

Table 1) Comparison of the average first three months power in Chahbahar port from 5 years water-wind data and three months experiments (*)

Time	Average effective height of wave (m)	Average temporal period (s)	The average power with accurate method (kW/m)	The average power with approximate method (kW/m)
Jan 1998	0.533	8.368	2.688	1.377
Jan 1999	0.711	8.375	4.247	2.273
Jan 2000	0.761	7.913	4.627	2.464
Jan 2001	0.584	9.204	3.139	1.69
Jan 2002	0.683	8.201	3.927	2.129
Average 5 years Jan	0.654	8.412	3.725	1.9866
Jan 2010 (*)	0.381	9.126	1.242	0.79
Feb 1998	0.585	10.06	3.448	1.884
Feb 1999	0.736	7.342	3.934	2.152
Feb 2000	0.737	9.745	5.203	2.892
Feb 2001	0.646	9.995	4.22	2.461
Feb 2002	0.689	9.192	4.319	2.403
Average 5 years Feb	4.225	9.267	0.679	2.3584
Feb 2010 (*)	0.575	7.485	3.745	1.914
Mar 1998	0.707	7.253	3.835	1.948
Mar 1999	0.76	6.827	3.645	1.986
Mar 2000	0.847	7.765	5.891	3.042
Mar 2001	0.614	9.111	3.737	1.939
Mar 2001	0.681	9.271	3.557	2.066
Average 5 years Mar	3.456	8.046	0.722	2.1962
Mar 2010 (*)	0.643	10.567	3.455	2.25
Average for 3 months wave experiments	0.5333	9.059	2.814	1.651
Average for 3 months water-wind model data	0.685	8.575	3.802	2.18

Conclusions

Considering the results of water-wind model for 5 years, the average annual waves in Chahbahar port is calculated between4.746 kW/m (approximate method) and 8.621 kW/m (accurate method). From comparison between experimental waves in three months, it is observed that the water-wind model in both accurate and approximate methods has predicted higher values than experimental measurements. Therefore, it is essential to do more experiments and to modify the water-wind model used.

References

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