Development of Ocean Energy Test Field in China

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Abstract: The mission of the test field is to provide technical support to associates. The paper present the development of OE (ocean energy) field in China and outline the new technologies and best practice, resources conditions, construction targets, generation device testing and standard system. The main purpose is to improve the level of China’s ocean energy development. The Chinese ocean energy test field, which was started in 2008, involved a development divided in three phases (the overall design, construction, demonstration). The methodology followed in the individual phases is described, and the standardization of testing wave and tidal current energy devices is introduced. The research revealed the development and the shortage of ocean energy technology in China.

Key words: Ocean energy, test field, device testing, standardization.

1. Introduction

Ocean testing field is a public technology platform, plays an active role in marine science and economic development [1]. In order to improve the level of marine technology, China began to construction of ocean testing field in recent years. China has long coastline and rich ocean energy resources. According to preliminary estimate, the theoretical potential of offshore Tidal range energy reached 192.86 GW, wave energy reached 7.7 GW, tidal current energy reached 8.32 GW, especially Zhejiang and Fujian provinces [2], shown in Table 1. Ocean energy as a new type of green renewable energy, get the attention of the local government and society. Local governments have introduced various planning, policies and incentives to encourage the development of technology, alleviate the pressure of the environment, and promote the development of ocean energy industry.

2. Main framework

2.1 The Regional Layout

Ocean energy test field is a major technology research and development platform, it is a long time project. From 2009, we began to overall design and distribution, the test field divided into three stations: NNOETS (Northern National Ocean Energy Test Station) will be built in the coastal of Weihai of Shandong province, NTCETS (National Tidal Current Energy Test Station) will be built in the coastal of Zhoushan of Zhejiang province, and NWETS (National Wave Energy Test Station) will be built in the coastal of Guangdong province, shown in Fig. 1.

The location of test station is in comprehensive consideration of the local natural environment conditions, resources conditions, traffic, employment, grid, economic feasibility, and after the argumentation of professional scientists.

2.2 Total Goal

The test field is to establish the oceanic general public testing platform [3]. Main job is to investigate and analyze hydrological and meteorological parameters, and study the method of device testing and assessment, optimization efficiency of energy acquirement and power transmitting [4].

To provide technology for the development of the national power generation device, prepare the way for industrialization [5], shown in Fig. 2.

NNOETS: located in northeast of Shandong province, was an early area of OE (Ocean Energy) test
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Table 1  Status of Ocean Energy resources in China.

<table>
<thead>
<tr>
<th>Types of MRE</th>
<th>Theoretical potential/GW</th>
<th>Technical potential/GW</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Tidal range</td>
<td>192.86</td>
<td>22.30</td>
</tr>
<tr>
<td>2 Tidal current</td>
<td>8.32</td>
<td>1.66</td>
</tr>
<tr>
<td>3 Wave</td>
<td>7.70</td>
<td>1.52</td>
</tr>
<tr>
<td>4 OTEC</td>
<td>367.00</td>
<td>25.70</td>
</tr>
<tr>
<td>5 Salinity gradient</td>
<td>113.08</td>
<td>11.31</td>
</tr>
<tr>
<td>6 offshore wind</td>
<td>980.43</td>
<td>570.34</td>
</tr>
<tr>
<td>7 Total</td>
<td>1669.39</td>
<td>633.36</td>
</tr>
</tbody>
</table>

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Fig. 1  Test station for MRE in China.

Table 2  Parameters of each Station.

<table>
<thead>
<tr>
<th>Station</th>
<th>Water depth</th>
<th>Mean wave height</th>
<th>Max current speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weihai Ocean Energy Test Station</td>
<td>50-70 m</td>
<td>1 m</td>
<td>1.2 m/s</td>
</tr>
<tr>
<td>Zhoushan Tidal Current Test Station</td>
<td>20-60 m</td>
<td>1.5 kW/m²</td>
<td></td>
</tr>
<tr>
<td>Zhuhai Wave Test Station</td>
<td>30 m</td>
<td></td>
<td>3×100 kW</td>
</tr>
</tbody>
</table>

Fig. 2  Public service platform for MRE in China.

current energy device, include optimizing, real sea testing, efficiency evaluation, environmental impact assessment, power transmission, grid connection and so on. Finally, built a demonstration power station which has a public test berth, to accelerate the commercialization development in China. NTCETS design of three test berth, contains testing system and ocean observing system, could satisfied 300 kW, 600 kW and 1 MW tidal current generator unit.

NWETS: located in Zhuhai of Guangdong province, is designed to testing and evaluation wave energy device, like NTCETS, it can optimize, real sea testing, efficiency evaluation, environmental impact assessment, power transmission, grid connection and so on. It can test the capacity more than 100 kW on wave energy device [6].

3. Build Ocean Energy Test Field

2008, NOTC (National Ocean Technology Center) started research and planning about ocean energy test field [7]. In 2010, with the support of national financial fund, we launched the engineering design work. After repeated arguments, until 2013, the location of NNOETS is confirmed, electric transmission and distribution, test platform and system have been carried out. At the same time, NTCETS and NWETS started, is expected after four years of time, China’s first ocean energy test field will open.

3.1 Tidal Current Energy Testing Platform

Tidal current energy testing platform offshore distance is 300 meters, the depth of the water is 20
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3.2 Transmission System of the Field

Transmission system consists of power distribution system, power transmission system and electrical test system, as a test platform, it can provide electricity generators and power management, research the design of distributed grid-connected power generation system and management methods. It is the main function of power distribution and transformer, current transformer and electrical testing, underwater cable laying and the environment impact assessment [8], shown in Figs. 3 and 4.

3.3 Real-Time Observation System

Real-time observation system of the testing field within the scope of 5 km² deploy one meteorological and hydrological observation system, and one waverider buoy, two bottom real-time observation system, 3 GPS wave buoy. The system measure wave, current, tide, water temperature, salinity, wind, temperature pressure and so on, and layout the most suitable testing plan for power generation device, shown in Fig. 5.

4. Device Production Design

4.1 Lab Testing

(1) Out experiment tank is under construction, the length is 130 m long, wide is 18 m, depth is 6 m. It can simulate the sea wave, current and wind, and it has a removable test platform. The Table 3 shows the parameters;

(2) Energy conversion efficiency testing tank is 25 m long, 1.6 m wide, 1.6 m high, the maximum working depth of 1.2 m, can provide simulated seawater environment test for physical model, shown in Fig. 6.

We use the NOTC gravity pendulum 1:5 scaled model for lab testing, set up different wave height and period. Then analyze conversion efficiency under various conditions, so as to determine the best transition conditions. Following is the result, shown in Table 4.

As a result of the limitation of wave range test device, the above test results are analyzed: at the same period, the wave height in a certain range to achieve the highest conversion efficiency; in condition of less wave height, period focused on the 2 s reaches the highest conversion efficiency, wave height is bigger, the periodic increase to reach the highest conversion efficiency, shown in Fig. 7.

4.2 Real Sea Testing

Wave testing station: total area 0.4 m², three test berths for single 100 kW floating wave power devices. The berth offshore distance is 300 m, 350 m radius. After testing, the device access to the demonstrate site,

![Fig. 3 Transmission and distribution system design.](image-url)
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demonstration operation have six berths, radius of 100 m, shown in Fig. 8.

Tidal Current Testing Station: site is still in the design stage, it has 3 testing berths, one shallow-water berth (depth of 10-20 m), two for deep-water berths (20-50 m depth), a single berth meet capacity 1 MW floating type or stationary power unit test, single berth is greater than 0.4 m², offshore within 3 km of distance, shown in Fig. 9.

5. Ocean Energy Standards

A common reference is important and necessary when comparing devices [9]. At present, China’s ocean energy research started late, laboratory and sea test standard is very lag, from device research and development, to the indoor test, and test to the sea. With the development of ocean energy technology, standard system will also gradually improve. In technology developed country, however, ocean energy standard is more, such as the IEA (International Energy Agency), EMEC (European Marine Energy Centre),

Table 4 Result of NOTC gravity pendulum 1:5 scaled model testing.

<table>
<thead>
<tr>
<th>Wave height (m)</th>
<th>Measure $H_{1/3}$ (m)</th>
<th>Convert efficiency (%)</th>
<th>Period (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.10</td>
<td>0.1126</td>
<td>4.41</td>
<td>2.02</td>
</tr>
<tr>
<td>0.12</td>
<td>0.1383</td>
<td>28.56</td>
<td>2.02</td>
</tr>
<tr>
<td>0.14</td>
<td>0.1521</td>
<td>29.35</td>
<td>2.02</td>
</tr>
<tr>
<td>0.16</td>
<td>0.1778</td>
<td>27.02</td>
<td>2.02</td>
</tr>
<tr>
<td>0.18</td>
<td>0.1961</td>
<td>29.06</td>
<td>2.02</td>
</tr>
<tr>
<td>0.20</td>
<td>0.2132</td>
<td>26.41</td>
<td>2.02</td>
</tr>
</tbody>
</table>
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6. Conclusion

Many parts of testing field are still under construction, a lot of test can not carry out, so we will face a lot of problems. Ocean testing field is a huge project, probably for many years to build, not a very good experience, lack of professional talents may be
the key problem. We will also continue to testing field research, like methods testing, standards testing, berth layout, data management, continuously improve standard system, and promote the industrialization development of ocean energy technology in China.

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