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# Testing Device for Hydrodynamic Characteristic on Conversion Devices of Tidal Stream Energy

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## ABSTRACT

The feasibility of tidal in stream energy conversion technology, especially the demonstration of the efficiency in energy conversion, is of consequence to provide efficient devices and cost-effective electrical energy. The excellent hydrodynamic model of the conversion devices is an essential condition of a successful tidal flowing power. The experimentation of the hydrodynamic model in laboratory should be first selecting by reason of the reliability and immediate data to assess the hydrodynamic characteristic. But, the simulation of a flowing condition in laboratory is not easily accomplished, as a result of need of bigger flowing speed and greater bigger flume. Based on the relativity principle, the relative testing method of the energy conversion technology in tidal stream was provided. The peculiarity, the structure of the testing device was indicated. The function of every composing proportion on the testing device was explained. The process of experimentation was introduced.

**Key words:** Tidal stream, Energy Conversion, Testing Device, Function of structure

## INTRODUCTION

Tidal current power generation is the largest form of ocean energy development and utilization. In china theoretical tidal energy resources is up to $1.1\times10^5$ kW, and Annual average power of tidal energy in shore is about $1.4\times10^7$ kW, which belongs to one of the biggest power density regions among the world[1].

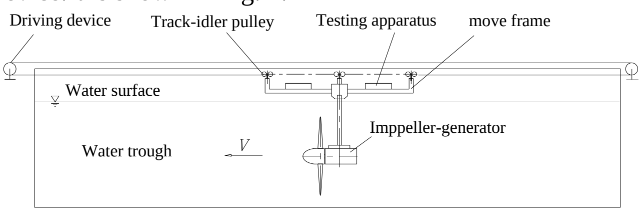
The tidal flow is mainly regarded as regular seawater flow caused by tide. The tidal technology for power generation is similar to the wind technology, utilizing the kinetic energy, not the potential energy stored by dam on shore. The turbo-generating equipment is installed in the tidal flow directly. Compared with offshore wind power generation, the density of seawater is about 800 times more than that of air, and the flow rate is about one-fifth of that. When output is at the same power, the diameter of tidal power blade is only about half of that of wind blade. In all the advantages of tidal power are obvious——the flow is more regular and stable, the energy density is bigger，and the blade diameter is much smaller. In last decade, new tidal current power technologies for generation and new devices emerge in an endless stream. Mw-class power equipment has been installed for power generation，making it develop commercial[2].

By considering that the development of tidal flow power is commercial, large-scale, high economic, one of the major conversion measures is to improve capacity of single machine, the maximization of conversion devices. RTT device designed by Luna Energy Ltd, 1.5MW unit, its blade diameter is up to 16m; SeaGen device designed by MCT's, its blade diameter is 18m. It is especially significant to insure excellent performance, high reliability and good economics for Large-scale installations. To keep large unit operate in good performance, the most effective and economical way is model test, and indoor model test is effective mean to conduct basic research and technical development.However, when the prototype and models are in scale , for the large size of prototype converter and fast flow speed ,it requires large experimental device which has a large capacity of supply water .So the realization of indoor test and economy of testing are difficult.

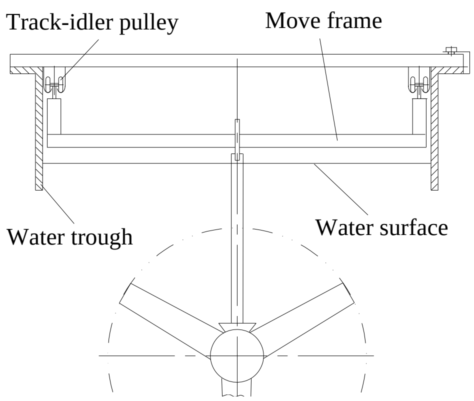
Research development should meet some requirements: scale effect, the laboratory conditions, equipment and methods with good economics.These improve the model efficiency and ensure the prototype performance, which are of great significance. Moreover, it conducts the basic theoretical research. This article, based on comparative theory, proposes a device and method for relative test.

## EQUIPMENT SYSTEM

The function of this device system is to provide water for the test system and simulated operating conditions, which composes of flume, guide wheel, mobile plate, drives, testing meter and instrument and the generator calibration device.It is shown in Fig. 1.




a)




b)

Figure 1 Schematic diagram of experimental device
a) Vertical section　　b) Across section

The impeller is installed on mobile platform and driven to move by mobile platform through the traction drive. So the relative movement effect is obtained.

Figure 2 is the system block diagram, indicating the relationship of energy transfer and the method determining the impeller efficiency.

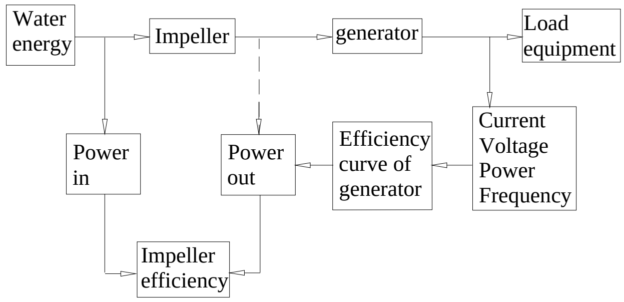



Figure 2 Block diagram of equipment system

### Flume

In this test device, the flume is only used as container for storage in which water does not flow. So appropriate pump can meet the test need, avoiding large diameter pump and high power motors, which not only saves lots of equipment costs, but amounts of energy.

The size of flume takes account of impeller moved distance, moving speed, impeller diameter and other factors. The flume section is mainly determined by impeller diameter; the flume length depends on the impeller moving distance and moving speed. The depth of flume equals to the width of flume, which can prevent water surface gush highly in front of impeller when mobile platform is moving at fast speed. Flume has overflow device.

The maximum relative running speed designed is 3 m/ s and the minimum measurement time designed is 5s. Taking into account the distance, the impeller running start and stop required, the measuring segment is 10 m.

The flume geometric sizes is as follows:

The flume Width: l. 2 m (the impeller diameter is800 mm, impeller blade tip is 200 ram from the side wall);

The flume High: l. 5 m (depth l.2 m, tip away 200 mm from the surface, 200 ram from the bottom);

The flume length is 25 m:

The flume capacity is 45 $m^3$;

The capacity of flume is 36 $m^{3.}$

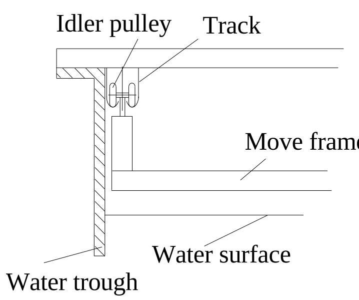



Figure 3 Rail guide wheel

### Track-idler pulley

Main function of guide rail wheel is to ensure impeller moving smoothly and un-vibrantly. The rail is formed by plate .As shown in Figure 3, hanging rail and wheel structure is adopted.

### Mobile platform

Main function of mobile platform is to install the impeller generators and provide a platform for measuring instruments. And the mobile platform is framework - flat structure

Mobile platform, which is connected with the guide wheel upside and equipped with wheels downside, moves smoothly in a straight line along the rail by driving force. And it drives the impeller - generator running by linkage connected with the impeller- generator.

Mobile platform can ensure linkage which is connected with impeller -generator move in two directions: up-down, forward- backward, in order to meet changes of impeller depth and changes of water depth, and changes of impeller axial thrust.

Measuring instruments for electrical parameters and mechanical parameters can be placed on mobile platform.

### Traction-drive device

Traction Drive device is to enable mobile platform movement, so as to drive the impeller to work. The device mainly consists of traction drive motor, reducer, wire rope and reel.

Drive motor is variable in speed. Reducer is installed between drive motor and wire rope reel to satisfy the speed of mobile platform and changes of this speed.

### Generator calibration device

In order to be able to evaluate the efficiency of impeller, the output power of the impeller is required, using the calibration of generators efficiency to converter from the generator Output power to the generator input power.

## TEST SYSTEM

The function of test system is to collect variety of measurement parameters, and transmit the collected data to the data processing system, for calculation, drawing, display, output and other processing.

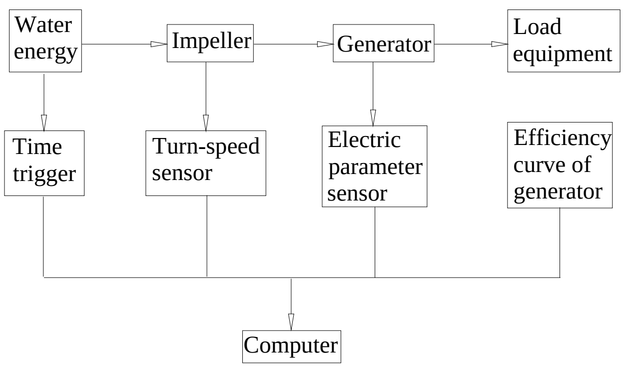



Figure 4 Parameter measurement systems

### Flow parameters

There are two types of flow parameters:

1. Physical parameters of water, including water density, temperature, viscosity, etc.

2. Water motion parameters generated by the system of installation, such as the relative velocity, caused by mobile platform, between the impeller and water this velocity is the tidal flow velocity simulated by relative test-bed shall for calculating tidal stream energy (or tidal power device input energy).

### Electrical Parameters

Electrical parameters are the output parameters of generator energy, mainly including current, voltage, frequency, power and so on, which are the output energy parameters of tidal power generation.

### Generator efficiency

Generator efficiency calibration system is shown in Figure 5. The electric motor is used as input power. The torque-speed transducer is equipped between the motor and generator for measuring the input power of generator. Output power of generator is measured by same instruments. The load device is also adopted, to adjust the load generators to get different electricity in power and different generator speed.

According to the data collected in the process of generator efficiency calibration, computer automatically draws power - speed-efficiency curve, digitally stored in computer，to determine the generator input power under instruments test condition, that is, the impeller output power.

Data between curves is obtained with interpolation method.

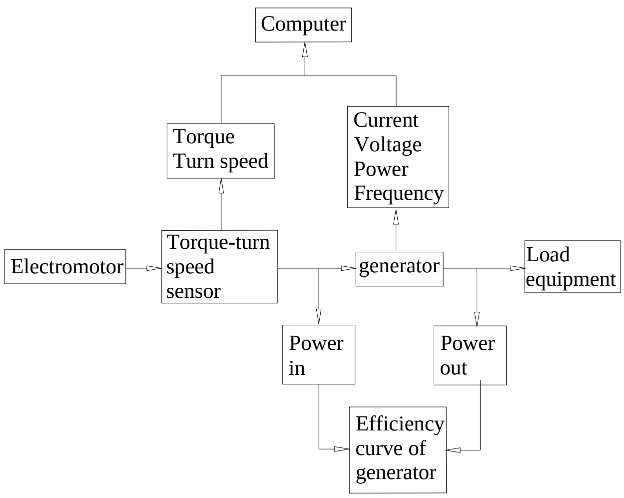



Figure 5 the calibration diagram of generator efficiency

## CONTROL SYSTEM

The control system includes speed control of mobile platform and parameters measurement control.

### Moving control of mobile platforms

Moving speed of mobile platforms is controlled by traction drive motor. In the start-up phase , the system enable the mobile platform get to the required moving speed within the specified time or distance; In the cessation of paragraphs, the system enable mobile platforms stop on the location of the pre-set range within the specified time or distance.

### Parameter measurement start, stop control

Parameter measurement start and stop control, which is to start or stop the collection and transmission of various parameters.

The designed start segment is 5m, stop segment is 5m (take into account the phenomena that water surface gushed high, the segment can be longer),and the section that operated stable is 15m.Then considering the stability of data in measurement, 10m is taken in middle where operation is stable. As the relative velocity is maximum (V = 3m/s), it would spend 3.3s to acquire the data. During this period, the impeller rotate about l6.5 turn (n = 300r/min).

## DATA ACQUISITION AND PROCESSINGAND TESTING ACCURACY

### Data Acquisition and Processing

During the same time dates are collected in equal interval from in measurement segment While at this time water parameters and electrical parameters are not synchronous, it would not affect the average of the calculated value, because the average of multiple sets of data is adopted in measuring segment.

$$\bar{x}_i = \frac{1}{n}\sum_{i=1}^{n} x_i \ ,$$

Where $\bar{x}_i$ = the average value of some parameters

$x_i$ = the measured values of some parameters in the order of i

n= times of some parameters acquisition

The moving speed of mobile platform (relative to the flow rate) is calculated, by the time that the mobile platform passed measurement segment.

$$V = \frac{L}{s}$$

Where L = the length of measurement section, m;

S=the time that the mobile platform passed measurement segment, S.

### Testing accuracy

The testing accuracy includes instrument error and random error.

1. Instrument Accuracy

All precision of electrical parameters transmitter is ± 0.2%, the precision of transmission speed sensor is ± 0.1%,

2. Random error

Multi-point averaging method is adopted to reduce random error.

## CONCLUSION

Based on comparative theory, relative test equipment and methods are developed to test the performance of tidal flow energy converter.

1. The test equipment and method can simulate tidal flow under its conditions in the laboratory, the test not only verifies mode performance, but can conduct basic research and technology development test.

2. The test device and method can be used in impeller-generator performance tests and the impeller efficiency test，which meet test conditions requirement for high-efficiency impeller technology and high efficiency unit .

3. The test device and method does not require supply equipment with large flow. These can save a lot of equipment investment, and a lot of energy consumption in running. So it has a good economic benefits, fine practicality and great applicability.

## REFERENCES

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