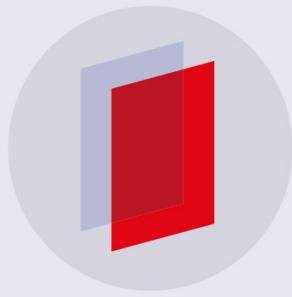


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## Study on Principle Design and Hydrodynamic Performance of Swing River Kinetic Energy Generation Device with Parameters

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# Study on Principle Design and Hydrodynamic Performance of Swing River Kinetic Energy Generation Device with Parameters

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**Abstract.** From the perspective of energy security, the development of renewable energy can solve the shortage of energy resources. From the perspective of environmental protection, the development and utilization of renewable energy can improve the deteriorating ecological environment in China. The equipment of river kinetic energy generation is different from that of conventional large and medium-sized high dam hydropower stations because of the different energy conversion modes. Due to the great differences in river conditions, the development of wave energy in China can not directly apply the successful experience of foreign countries. The mathematical model of motion simulation is based on the simulation of mechanism system. It can truly reflect the motion performance and energy utilization of a given mechanism to a certain extent. In this paper, the mathematical model of the motion simulation of the tank test model is established by analyzing the motion of the blade hydrodynamics and the pendulum energy conversion device. The device capture power obtained by experiments is compared with the device capture power obtained by the frequency domain numerical model, which verifies the rationality of the experimental arrangement and the reliability of the experimental data.

## 1. Introduction

Energy is an important basic resource for the development of human society. Without energy, there would be no human civilization. According to the type of use, energy can be divided into traditional conventional energy and new energy [1]. Conventional energy includes renewable water resources and non-renewable fossil energy such as coal, oil and natural gas. At present, the global petrochemical energy is gradually exhausted and the price of gasoline is rising. It is difficult to meet the cost-effectiveness and demand of automatic pumps driven by electricity or gasoline [2]. In the absence of effective solutions, agricultural modernization stagnates and large-scale labor waste. From the perspective of energy security, the development of renewable energy can solve the shortage of energy resources [3]. From the perspective of environmental protection, the development and utilization of renewable energy can improve China's deteriorating ecological environment. In this regard, we propose a new type of first-class water-swing engine that can generate electricity using water flow energy. There are many technical bottlenecks in the development and utilization of wave energy, and the development cost is high [4]. River flow energy generation equipment is different from conventional large and medium-sized high-dam hydropower stations because of the different ways of



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energy conversion. However, in the long run, it is of great practical and strategic significance to increase investment in the research and development of wave energy conversion devices.

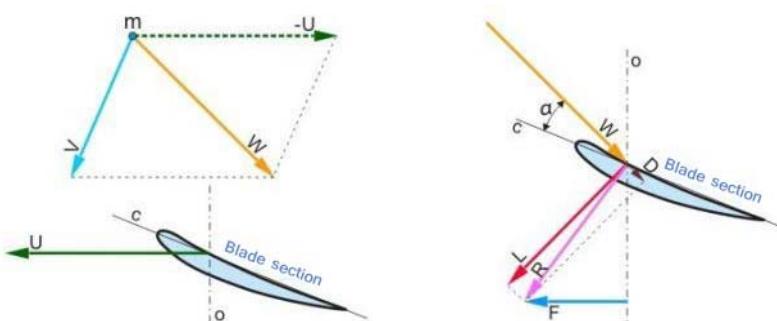
The adjustment of energy structure and the development and utilization of renewable energy are urgent. Due to the direction of wave propagation and the instability of wave elements, the dynamic performance of wave energy conversion devices is often in a non-ideal state, which indirectly leads to a further increase in power generation costs [5]. The new river energy generating device can better adapt to the river's environmental characteristics, and can have good system performance, simple and reliable structure and low construction and operation and maintenance costs. The development of renewable energy can form new economic growth points [6]. The velocity of tidal current is proportional to the tidal range, but the topographic effect can not be ignored. Our products do not use electric energy but use kinetic energy of water as energy input to drive water pumps, and ultimately achieve the goal of pumping water with zero power consumption, which is economical and environmentally friendly [7]. The research and development of buoyancy pendulum wave energy conversion device in China is relatively lagging behind. Due to the great difference of river conditions, the development of wave energy in China can not directly apply the successful experience of foreign countries [8]. It is of great significance to adjust the industrial structure and promote the sustainable development of economy and society. Developing and utilizing renewable new energy such as tidal current energy and realizing diversification of energy supply become an effective way to alleviate energy shortage and ensure energy supply.

## 2. Materials and Methods

The pendulum River kinetic energy generating device is suitable for the application of river kinetic energy in principle, and the characteristics of river structure and flow should be fully considered in the design. The pump body consists of a suction chamber and a pressure chamber. The inlet and outlet flanges of the suction chamber are pump inlet flanges and outlet flanges respectively, which are used to connect the inlet and outlet pipes. The function of the suction chamber is to introduce water flow into the impeller and provide the required flow pattern to the impeller. The function of the pressure chamber is to collect the liquid from the impeller and to direct the flow to the outlet [9]. It is necessary to further study the hydrodynamic performance of buoyancy pendulum device by using physical model experiment. There are many similarities between the kinetic energy of water flow and the utilization of wind energy, so some wind turbine technologies have been transplanted into the flow kinetic energy generation. The energy harvesting device converts fluid kinetic energy into rotational or translational mechanical energy of the device. The mechanical transmission system transmits the rotating or translational mechanical energy to the generator through a transmission mechanism such as a shafting, a gear or a slide.

Let the mass flow rate of water be  $G$ , the water flow velocity be  $u$ , the relative velocity of the inlet is  $w_1$ , the relative velocity of the outlet is  $w_2$ , the inlet angle of the water inlet is  $\beta_1$ , and the exit angle is  $\beta_2$ , then the power is:

$$P = Gu(w_1 \cos \beta_1 + w_2 \cos \beta_2) \quad (1)$$



**Figure 1.** Speed triangle

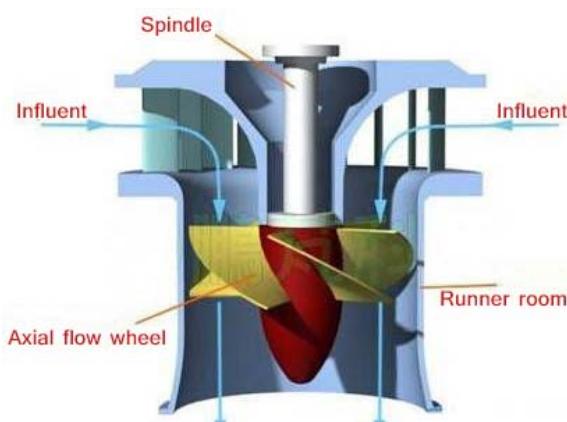
As a river floating structure, the floating tidal power generation device needs to be fixed in a tidal-rich river and guarantees a certain period of power generation operation, and is generally positioned by a mooring system. The figure shows the impeller speed triangle.

The control system is a software and hardware system that realizes safe and stable operation, power generation, start-up and shutdown, power conversion and system protection of the generator set through automatic control or manual control. The flow pendulum engine can be adjusted by adjusting the engine unit in an environment with harsh working conditions and high flow rate. In the numerical model, the amplitude of the corner under the unit wave amplitude increases as the incident wave period increases, reaching a maximum near the natural period. In physical model experiments, the angular amplitude per unit wave amplitude increases with the increase of incident wave period. Regarding the design of performance test prototype of pendulum River kinetic energy generating device, based on the requirement of laboratory test of power and hydrodynamic characteristics, generator, detection system and load system will be considered. The time history diagram of rotation angle of buoyancy pendulum shows strong non-linear effect, and the amplitude of rotation angle is larger. In the model experiment of the bottom of the buoyancy pendulum, the damping moment has little effect on the rotational amplitude of the buoyancy pendulum.

### 3. Result Analysis and Discussion

The monitoring system is a kind of sensor, signal acquisition and transmission system which detects the parameters of power generation device and operating environment. It cooperates with the control system to ensure the safety of the system. Typical structures, key components or systems of power generation devices should be designed, manufactured and installed as modularized as possible to improve reliability and reduce the cost of manufacturing, installation and maintenance of the system. When water flows through the cascade, the component of the relative velocity in the circumferential direction changes, that is, the flow momentum in the cascade channel changes in the circumferential direction. This change indicates that the cascade exerts a force on the flow. The change of water flow in cascade passage is equal to the impulse of cascade acting on water flow. The actual output wave of the pool wave machine is different from the input wave making parameters. The buoyant pendulum wave energy conversion device has a large rotation angle. However, when there are two square boxes at the bottom of the oscillating plate and there is a square box, the difference in the angle of rotation of the buoyant oscillating plate is not obvious. A compartment has a limited change in the overall moment of inertia of the pendulum.

The liquid filled with the impeller is subjected to centrifugal force and is scooped out from the periphery of the impeller. The high-speed flowing liquid collects in the pump casing, and the speed is lowered and the pressure is increased. Figure 2 shows the structure of an axial flow impeller.



**Figure 2.** Axial flow impeller structure

In the mooring test, accurate measurement and adjustment of the center of gravity and moment of inertia of the catamaran model and the turbine model are required. The impeller rotates at high speed in the pump casing to generate centrifugal force. The mathematical model of motion simulation is based on the simulation of the mechanism system, which can reflect the motion performance of a given mechanism and the energy utilization rate that can be achieved to a certain extent [10]. The natural period of the device measured by the free-release experiment is compared with the natural period of the device obtained by numerical calculation. The results of motion simulation are smaller than those of blade motion without considering the constant velocity ratio of induced velocity. However, the influence of induced velocity is not taken into account in the mathematical model of motion simulation program. By comparing the device capture power obtained by experiment with that obtained by frequency domain numerical model, the rationality of the experimental arrangement and the reliability of the data measured by experiment are indirectly verified.

#### 4. Conclusion

Swing River kinetic energy generating device is a new kind of flowing water kinetic energy conversion device. At present, the research on the performance of the swing River kinetic energy generating device is in the preliminary stage of exploration, and there are still many problems to be solved. Based on the analysis of blade hydrodynamics and swing energy conversion device motion, the mathematical model of flume test model motion simulation is established. Accurate measurement and adjustment of roll inertia, pitch inertia and bow inertia of the model are realized by the principle of dynamic moment balance, and the measuring and adjusting device of the center of gravity and the moment of inertia of the model is developed. When the wave element is large, the dynamic history curve of the hydrodynamic pressure on the surface of the buoyant pendulum plate is severely distorted, and the nonlinear effect of the wave is strong. When the wave element is fixed, the dynamic water pressure on the surface of the buoyant pendulum increases with the increase of the damping torque. The existing diversion irrigation pump has a submersible pump, but the prime mover of the pump is a motor, which consumes a large amount of electric energy if driven for a long time. Since the blade load is pulsating, the blade vibration cannot be ignored when the type of device is enlarged. Vibration not only adversely affects the structure but also affects the hydrodynamic characteristics of the blade. The hydroelastic response and reliability of the blade become critical.

#### References

- [1] Yip N Y, Vermaas D A, Nijmeijer K, et al. Thermodynamic, Energy Efficiency, and Power Density Analysis of Reverse Electrodialysis Power Generation with Natural Salinity Gradients. *Environmental Science & Technology*, Vol. 48 (2014) No. 9, p. 4925-4936.
- [2] Gao J, Guo W, Feng D, et al. High-Performance Ionic Diode Membrane for Salinity Gradient Power Generation. *Journal of the American Chemical Society*, Vol. 136 (2014) No. 35, p. 12265-12272.
- [3] Boultee N. Upper Lillooet River Hydroelectric Project: The Challenges of Constructing a Power Tunnel for Run-of-River Hydro Projects in Mountainous British Columbia. *Engineering*, Vol. 4 (2018) No. 2, p. 260-266.
- [4] Deines A M, Bee C A, Katongo C, et al. The potential trade-off between artisanal fisheries production and hydroelectricity generation on the Kafue River, Zambia. *Freshwater Biology*, Vol. 58 (2013) No. 4, p. 640-654.
- [5] Eftekharnejad S, Vittal V, Heydt,, et al. Impact of increased penetration of photovoltaic generation on power systems. *IEEE Transactions on Power Systems*, Vol. 28 (2013) No. 2, p. 893-901.
- [6] Kim Y C, Kim Y, Oh D, et al. Experimental Investigation of a Spiral-Wound Pressure-Retarded Osmosis Membrane Module for Osmotic Power Generation. *Environmental Science & Technology*, Vol. 47 (2013) No. 6, p. 2966-2973.
- [7] Kumar D, Katoch S S. Sustainability Assessment and Ranking of Run of the River (RoR)

Hydropower Projects Using Analytical Hierarchy Process (AHP): A Study from Western Himalayan Region of India. *Journal of Mountain Science*, Vol. 12 (2015) No. 5, p. 1315-1333.

- [8] Hasler C, Guimond E, Mossop B, et al. Effectiveness of pulse flows in a regulated river for inducing upstream movement of an imperiled stock of Chinook salmon. *Aquatic Sciences*, Vol. 76 (2014) No. 2, p. 231-241.
- [9] Zhang B, Gao H, Chen Y. Enhanced Ionic Conductivity and Power Generation Using Ion-Exchange Resin Beads in a Reverse-Electrodialysis Stack. *Environmental Science & Technology*, Vol. 49 (2015) No. 24, p. 14717-14724.
- [10] Karalekas P, Kowalski G J, Lovelace E. Modeling Hydrokinetic Turbine Performance in the Mississippi River. *Marine Technology Society Journal*, Vol. 47 (2013) No. 4, p. 57-66.