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# Design and optimization of one kind stream micro water power generation device

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**Abstract**: The streams has a certain amount hydro energy, can be used to generate electricity as a kind of clean energy, the use of streams and water to generate electricity has both realistic economic significance and important ecological and environmental protection. The purpose of this paper is to design one kind generation device which can be used in the low water head and rapid stream flow, according to water head and flow condition, the form of the generator was preliminarily designed, in order to realize the optimization of plant design and development, Numerical results showed that 8 degrees angle of outlet channel performed less loss; The shape type optimization design is carried out for generator room support column. After optimization, the performance improved greatly, and the power output increased from 13.9kW to 14.7 kW, and the efficiency increased from 73.5% to 78.3%.

## 1. Introduction

Micro water energy as a clean water energy, more and more attention in recent years, it as a kind of form is more flexible, more widely distributed form of energy, both can satisfy the requirement of a certain power, and environmental protection features extremely [1~7]. Stream as a kind of micro water energy, is widely distributed in our country and even the whole world [8~12], the development and research of stream power generation device and appear very necessary [13~18], also has a broad application prospect [19 ~ 20].

In this paper, the design of a stream with high water head and high flow rate is chosen for the water supply with natural head difference. This paper intends to develop a power generating device that does not need to use water pressure mainly as conventional hydropower, but relies on the flow of streams to generate the input energy needed to generate electricity.

## 2. Preliminary design of stream power plant

The basic data of stream flow in this paper is shown in table 1:

**Table 1.** Stream current basic data

| parameter | value |
| --- | --- |

| | |
|---|---|
| Mean annual head Ha (m) | 2.1 |
| The smallest head Hmin (m) | 1.8 |
| The biggest head Hmax (m) | 3.4 |
| The average flow rate Q (m3) | 0.935 |

Reference of turbine output calculation formula and the low water head water turbine speed and the application of the curve of water head than it is concluded that the empirical formula, can be calculated respectively is proposed to design output of the generating set and specific speed values, as shown in table 2:

Compared with the value of rotating speed, the high ratio speed water turbine is selected to adopt the form of the horizontal axial flow arrangement, and the generator is installed in the generator room, choose the basic parameters of the prototype turbine is the model conversion, determine the proposed design of the power generation device wheel diameter D1 and rotational speed n, as shown in table 2:

**Table 2.** Parameters of generator

| parameter | value |
|---|---|
| Water turbine output P(kw) | 14 |
| Specific speed (m.kw) | 955 |
| Diameter of wheel D1(m) | 0.6 |
| Rated speed n (r/min) | 375 |

This device is designed to reduce the hydraulic loss of water flow in the circulation channel and to improve the extraction rate of the flow energy through the blades. The outer casing is composed of three parts, import shrinkage tube, wheel chamber, and outlet diffusion tube. The inlet runner adopts the contraction tube, its section shape is round; the outlet channel adopts the diffusion tube, the inlet section of the outlet is round, the outlet section is rectangle, and the cross section of the circular variable is adopted. Design the micro power generation, its main components are import port and outlet port, wheel, wheel blade, hub, sticks, generator room, specific as shown in figure 1: Three dimensional blade of hydraulic turbine and Generator cabin support column as shown in figure 2.

As shown in figure 1, Inlet channel 1, runner chamber 2, hub 3 runner blade 4, outlet diffusion tube 5, support column of generator room, generator and generator room 7. Stream channel 8, Dip angle of Stream channel

As shown in figure 2: The generator is arranged in the generator room 7, and the generator room7 is fixed on the flow passage through the support column 6, and is provided with four support columns, namely 6-1, 6-2, 6-3 and 6-4 respectively.

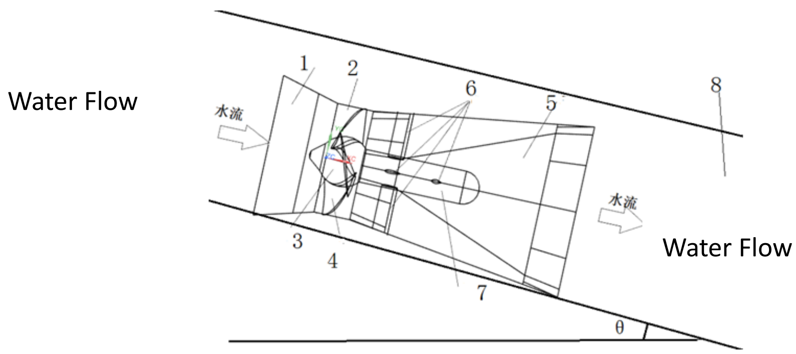


**Figure 1.** Flow line design of micro-water power plant

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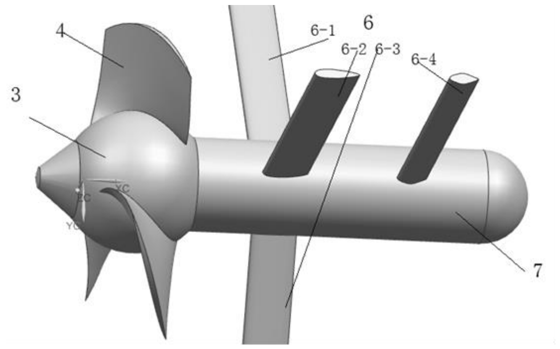



**Figure 2.** Three dimensional blade of hydraulic turbine and Generator cabin support column

## 3. Numerical simulation

Numerical simulation of the main process is: aiming at specific problems to choose control equation, establish the boundary and initial conditions, computational grid, determine the discrete control equations and boundary conditions, by a given control parameter to solve the discrete equations. The grid partition diagram of the wheel runner is shown in figure 3, and six main cross-sections are set as showed in figure 4.

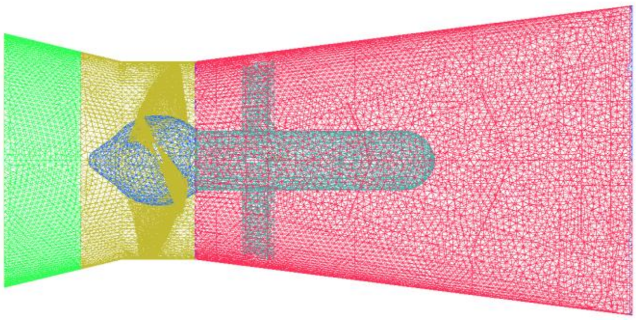


**Figure 3.** The grid division of the runner

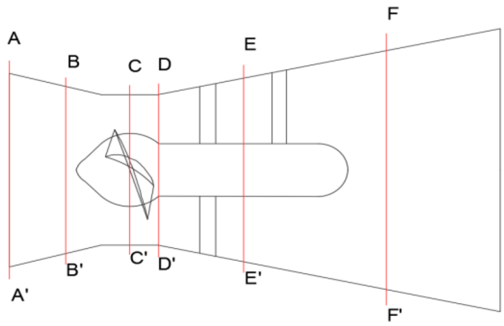
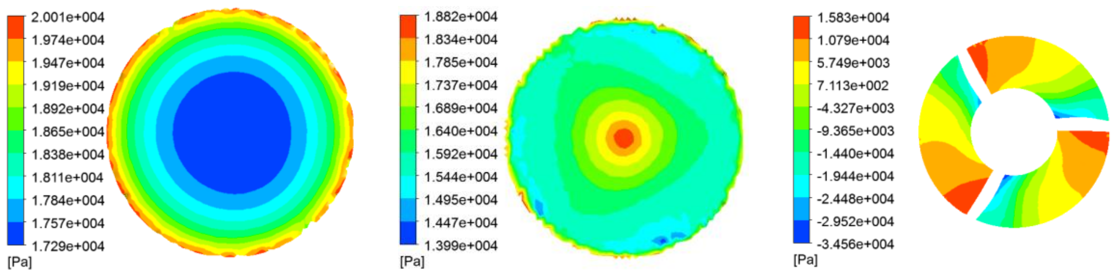


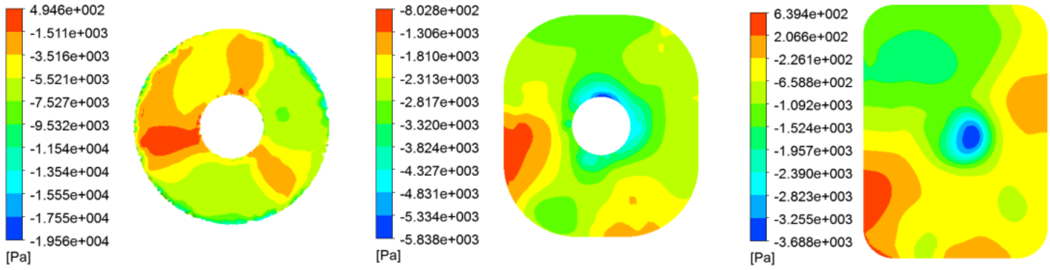

**Figure 4.** Six main cross-sections

The efficiency calculation of water turbine is determined as 73.5%. The results of CFD-post generated by post-processing software can quickly and intuitively observe the numerical calculation results of micro-turbine, showing the flow characteristics and existing problems.

• Pressure cloud diagram




(a)A-A (b)B-B (c)C-C




(d)D-D (e)E-E (f)F-F

**Figure 5.** Cross-sectional pressure diagram

- Velocity vector graph and trace diagram

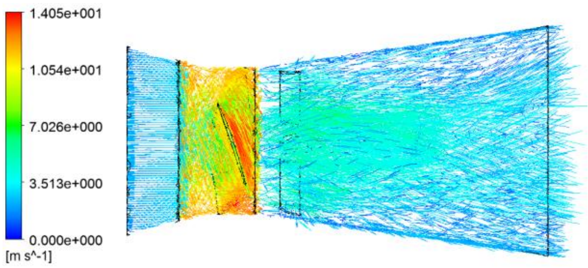



**Figure 6.** Velocity distribution of flow path

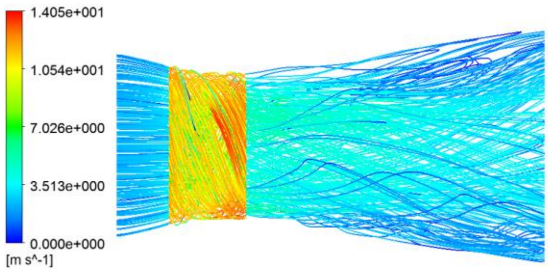



**Figure 7.** Flow trace diagram

It can be seen that when the water flow from the left side enters, the flow state of the inlet flow and the rotation zone are better and smoother. However, the flow of water flow in the outlet flow channel is more turbulent, which shows the phenomenon of backflow and eddy flow. The lateral flow state is poor and the pressure distribution is uneven.

## 4. Optimization design

### *4.1. Channel support column*

Comparing the schemes of the channel support column, the cross section of support columns were chosen as rectangle, diamond and airfoil respectively.as showed in table3 generation device efficiency of different support columns differ greatly, and the best form is airfoil.

**Table 3.** Generation device efficiency of different support columns

| support column form | rectangle | diamond | airfoil |
|---|---|---|---|
| efficiency | 73.5% | 76.5% | 78.3% |

### *4.2. Optimization of diffuser angle in outlet*

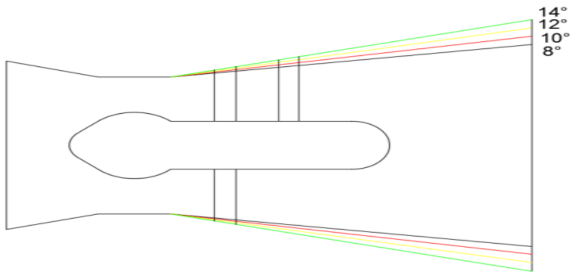



**Figure 8.** Diffuser angle of outlet diffusion tube

To export port side put Angle is optimized, comparison and analysis the $8^0$, $10^0$, $12^0$, $14^0$ outlet Angle when the flow pattern of flow passage, as showed in figure8 reasonable choose $10^0$ export Angle, water flow smoothly, and will choose in order to adapt to the column propping up of runner shape on the airfoil shape of the flow of water. The optimized pressure cloud map, velocity distribution and trace diagram are shown in figure 9-11:

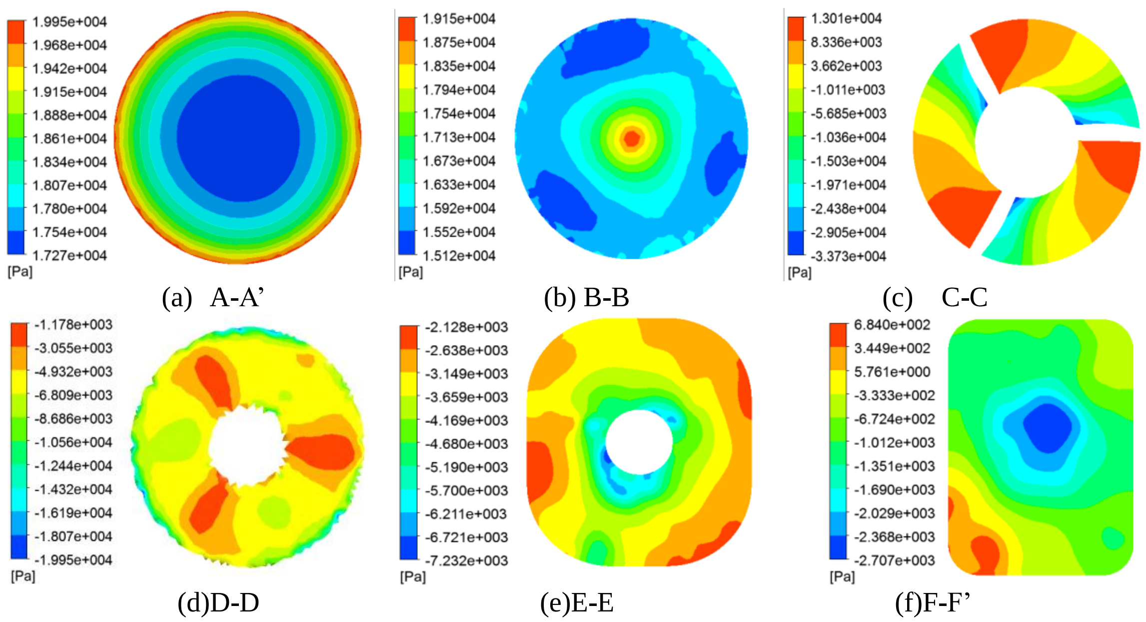



**Figure 9.** The pressure diagram of each section after optimization

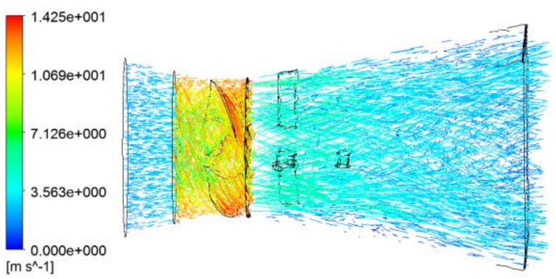



**Figure 10.** Velocity distribution after optimization

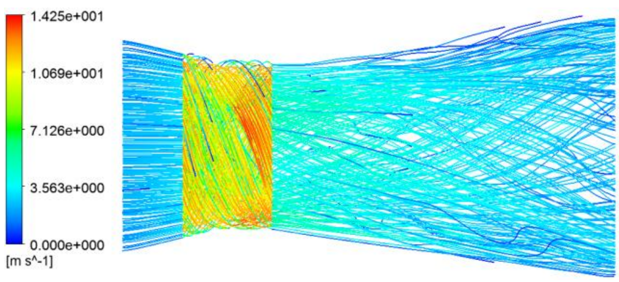



**Figure 11.** Optimized post-flow trace diagram

Compared with the pressure distribution of the previous sections, the pressure distribution of each section was more uniform. The flow velocity in the outlet flow is corrected, the streamline is smoother in the optimized flow line distribution, and the reflux and eddy current in the outlet flow are relieved. The force increased from 13.9kW to 14.7kW and improved 0.8kw. The optimized efficiency reached 78.3% and was up 4.8% before optimization.

## 5. Conclusion

In the paper developed one kind power generation device is a new model of the low head hydraulic resource, it is a port approximation for horizontal spindle straight tubular turbine, and it is not a diversion volute, made on the wheel hub blade of the paddle blade. This kind of water turbine flow condition is good, the flow is flat, the same flow area, water flow through easily, the unit flow is bigger. Moreover, there is no need to set up the volute and elbow pipe, and the flow hydraulic loss is small, the operation efficiency is relatively high, and the application of low water head has obvious advantages.

The diffusion Angle of the export of about $8^0$ ~ $14^0$ performance comparison, results show that the performance loss in $10^0$ export Angle smaller; the wing type optimization design is carried out for the runner support column. After optimization, the performance improved greatly, and the output increased from 13.9kW to 14.7 kW, and the efficiency increased from 73.5% to 78.3%.

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