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Thinking and Research of distributed generation in rivers

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Thinking and Research of distributed generation in rivers

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ABSTRACT: Aiming at maximizing the benefit of water resources utilization and ignoring other functions of the rivers, the hydropower development fundamentally changes the composition, structure and function of river ecosystem, breaks the original ecological balance. The dam has a great impact on the reservoir area and the ecological system of the whole river. The direct-flow power generation project in rivers is a new energy development technology. The results show that the cross-flow turbine with vertical shaft has higher power generation efficiency, and when the flow changes greatly, it can still maintain higher efficiency by the appropriate regulation.

1. INTRODUCTION

There are abundant direct-flow hydraulic resources of rivers in China, such as Brahmaputra Valley, Yangtze River, Yellow River and large lake gates. The distributed hydropower is a kind direct-flow power generation project. Considering the integration of energy, resources and environment, the distributed hydroelectric project can avoid the construction of reservoir dams, migration losses, and it is more beneficial to the ecological environment. The distributed hydroelectric project is similar to wind power generation, belonging to the ecological power generation technology and it has the advantage of environmental protection. In the past 2003-2020 years, 243 key reservoir construction projects have been planned and constructed nationwide. At present, China has become the country with the largest number of reservoirs in the world. The reservoir dam has great influence on the ecosystem of the whole basin. Hydropower projects should have a long-term concept of environmental protection. Under the current situation, we need to make an in-depth study of the ecological impact of the reservoir. In the future hydropower project construction, it is necessary to make full use of water resources to carry out reservoir construction, but also to consider the feasibility of carrying out the distributed generation projects to design the ecological power generation projects, maintaining the stability of river ecosystem and environmental protection responsibility.

2. Influence of reservoir on ecological environment

In order to maximize the utilization efficiency of hydropower resources, the large-scale reservoirs of the river development and construction have brought about great impact on river ecosystem. It is mainly in the following aspects:

2.1 Impact of reservoir construction on water quality[1,2]

It is estimated that about 170 km³ of water is evaporated from reservoirs around the world each year, which is more than 7% of the total fresh water consumed by all human activities. For example, the Nasser Reservoir is evaporated 11.2 km³ of water a year from the Aswan Dam on the Nile in Egypt, it is equivalent to 10% of the reservoir's water storage. The amount of water evaporated from the Hoover dam on the Colorado River in US is 1/3 of the river's discharge. The evaporation of reservoir water causes river salinity. In addition to increasing the salinity of river water, the chemical, thermal and physical changes



that flow water undergoes at rest can seriously pollute a reservoir and its downstream rivers. Generally speaking, the degree of degradation of river water quality is related to the retention time of reservoir water. The water stored behind the dam for several months or even years is fatal to the organisms of rivers tens of kilometers below the dam. The dam also intercepted nutrients while retaining sediment. These nutrients make eutrophication easier for reservoirs. At higher temperatures, algae and other organisms are overbred in nutrient-rich reservoirs, causing the water to emit an unpleasant odor. The Aswan Dam in Egypt (second only to the Three Gorges Dam) not only deteriorated the ecology and environment of the coastal watershed, but also had a negative impact on the economic and social development of the whole country. For example, the dam project caused the arable land along the river basin a continuous decline in soil fertility, along both banks of the Nile, soil salinization, serious erosion of the lower Nile River bed, the Nile estuary coastline recession.

2.2 Impact of reservoir construction on Regional Ecology[2]

The dam has blocked the passage of migratory fish, affected species exchange, and changed the aquatic animals and plants and their habitat in the lower reaches of the reservoir. Reservoirs have greatly increased the number of plankton and markedly altered the distribution and number of micro-invertebrates (usually reduced species), even if insects, mollusks and shellfish have lost their living environment.

2.3 Impact of reservoir construction on inundated population[2]

The construction of reservoirs on rivers will bring flooding to the reservoir area and the submergence of the land near the reservoir area. Up to now, there are more than 15 million reservoir immigrants in China, which is the largest reservoir immigrant country in the world. Reservoir resettlement work has always been one of the key points in water conservancy work.

2.4 Reservoir induced earthquake[1]

At least 70 reservoirs in the world produce induced earthquakes, it usually is caused by dams over 100 m high and reservoirs over 1 billion m³ in capacity. This is related to the cracks in the rock around the reservoir, which are related to the additional pressure of reservoir water and dams. The largest earthquake triggered by the reservoir was the 6.3 magnitude quake at the Koina Reservoir in India on December 11, 1967, which leveled Konaga in Maharashtra, killing 180 people, injuring 1,500, leaving thousands homeless, dams badly damaged, hydropower stations halted, and the power supplies in Mumbai paralyzed. China has 14 reservoirs triggered earthquakes, the largest of which was the 6.1 magnitude earthquake of the Xinfengjiang Reservoir in Guangdong Province on March 19, 1962, the earthquake intensity in the dam area was 8 degrees. More than 20 counties and cities within 200 kilometers around the dam were damaged, more than 20,000 houses were destroyed, more than 1,800 collapsed and 85 people died. During the earthquake, the dam shook violently, horizontal cracks penetrated through the dam, and the power plants and ancillary facilities of the dam were destroyed.

2.5 Methane generated by tropical dams[3]

Hydropower is usually considered to be an emission free power resource. This is true in temperate regions of the world, the situation is rather complicated in tropical areas. Bacteria live on organic matter in a hypoxic environment deep in a tropical dam reservoir, and the by-product of this process is methane released by bacteria (which traps heat 20 times as efficiently as carbon dioxide). Scientists at Brazil's National Space Institute estimate that methane released by some of Brazil's hydropower facilities in this way has a greater impact on climate than carbon dioxide emitted by thermal power plants with the same output power. It is estimated that the total impact of methane emissions from dams operating in tropical environments around the world is equivalent to 800 million tons of carbon dioxide, which exacerbates greenhouse emissions on the planet, a huge environmental burden.

3. Distributed generation (ecological power generation)

Distributed generation (ecological power generation) belongs to a new energy development technology, which uses natural flow of river water to generate electricity. Due to the short history of development, river natural flow power generation has many problems, such as simple technology and lack of experience in basic research and industrial operation. Especially in the research of the energy conversion devices, there is no mature technology in the world, and a lot of research is needed. Unlike wind power generation and ocean tidal current generation, river water flow unidirectionally and river water direct current (DC) turbine can achieve higher efficiency by setting up water guide mechanism. Our study further shows that, compared with other types of DC turbines, the DC crossflow turbine with vertical shaft has higher power generation efficiency, and it can still maintain higher efficiency by the appropriate regulation when the water flow changes greatly. The research and development of distributed generation focuses on the environmental impacts and aquatic ecological environment impacted by the dam storage-hydropower development.

The main advantages are:

firstly, distributed generation uses natural flow of river water to generate electricity, which occupies a small volume in the river. Only the part of the water flow is used to drive the turbine to generate electricity without affecting the water quality.

Secondly, distributed generation does not need to build reservoirs, less investment in construction, fast construction; not to occupy arable land, little impact on the surrounding ecological environment.

Thirdly, fish and other underwater organisms can bypass distributed generators, even if they pass through the turbine, because of its slow speed, they will not be harmed.

Fourthly, it will not induce earthquakes and produce greenhouse effect.

In the world, the use of distributed generation is in the initial stage of development. The so-called distributed generation, power generation devices scattered on the river surface, the natural flow of river water is used to drive turbine power generation. Because of its large structure and slow speed, the turbine has no impact on the river ecological environment, which can also be called ecological power generation. The turbine, developed by Professor Gorlov of Northeast University's Department of Machinery, can convert 35% of the kinetic energy in running water into electricity, while the conversion rate of the Darrieus turbine is 23%, and that of the ordinary turbine is 20%, that is a great success [4]. The cost of installing a distributed generation facility on a river is about \$400 to \$600 per kilowatt, much lower than the cost of fossil fuel power plants and ordinary hydroelectric power plants. Distributed generation facilities installed in rivers, people can not hear the noise when working, basically no significant impact on the environment. The Russian Institute of Energy Structure has developed a new type of DC turbine with 75% efficiency. The turbine has a diameter of 5 meters, it has the advantages of simple design and easy manufacture, and suitable for natural flow power generation of river water.

4. Crossflow turbine with vertical shaft

In recent years, we have also developed a river natural flow turbine with a power of 200-1000KW and an efficiency of over 75%. (Fig1,2. Vertical shaft turbine and diversion device). The runner of the crossflow turbine shaft is connected with an underwater foundation by vertical. Water flows into the turbine inlet and the first impact blade, and the first energy conversion takes up 72% of the total energy. When the water flows from the center of the runner to the outlet channel, the second impact on the blade makes the second energy conversion account for 28% of the total energy, and the turbine efficiency is about 75%.

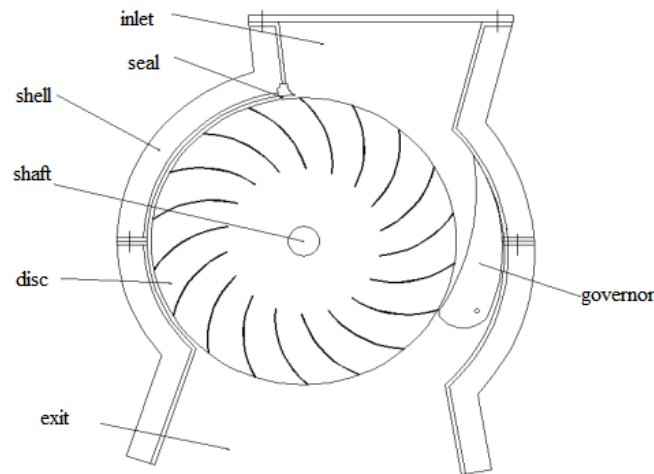


Fig1. Vertical shaft turbine

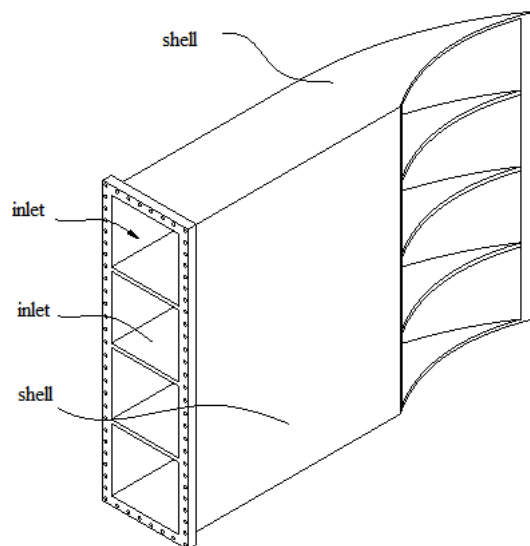


Fig2. Diversion device

5. Result analysis

Facing the contradiction between the current river hydropower development and ecological environment protection, the key is to combine the short-term project economic benefits of hydropower development with the long-term ecological economic benefits. While developing traditional large-scale hydropower projects in some river basins in China, the distributed hydroelectric power generation (i.e. ecological power generation) can be used as a complementary way to maintain the ecological environment. The most traditional and the modern comprehensive development concept of river basin is used to develop water resources, and the interaction between river ecological environment and hydropower projects is correctly evaluated and predicted. On the basis of balancing the current economic benefits and long-term environmental benefits of water conservancy projects, the reasonable methods and measures are explored to make the development of hydropower projects in the direction of beneficial ecological environment and jointly maintain the harmony of the earth's ecological environment.

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