THE PRACTICE OF COMPREHENSIVE SILT PROOF MEASURES IN TIDE POWER STATIONS

Xiaohua Liu and Liu Fagong

Shandong University , Jinan 250061, China

Tel.: 86-531-2955081-2681

Abstract: Comprehensive management plays an important role in ensuring the normal operation of tide power stations. Effective measures are obtained through a thorough theoretical study and a long-term investigation, which include:

1. Rational project arrangement

2. Appropriate operation mode

3. All sorts of essential engineering facilities

4. Effective mechanical sand-proof methods

5. Biological measures

All these above are the measures widely used in the tide power stations in China along the West Pacific coast and remarkable results have been achieved.

Keywords: practice, measures, tide, stations, silt proof

1 GENERAL SITUATIONS

1.1 The project

BaiShakou tide power station is located in seashore, Shandong Peninsula. It was put into use on 1, august, 1978 and the first two generators began to operate in 1984. The reservoir area, the BaiShakou lagoon, connects with its shape like a falcate with an of 3.2km^2 .The lagoon connects with the BaiShakou. It has many advantages with a big gulf, small mouth and good enclosure. The north coast is a kind of complex sand dam, 3.5km long, 1.0km wide. It connects the eastern sand proof embankment for 8km long. There is a bedrock coast in the west, with folded lines.

In the southeast of the lagoon, there is a mouth gate, which is 500m wide, and where there are three pivotal the dam, the water inlet gate and the power station. The dam is at the mouth of the main flow. The water inlet gate and the power station are in turn at the west side of the dam. Buildings of the power station are located west to the water inlet gate. There are six shaft tubular generators.

1.2 Take the generation tail water sand-proof

The equation for calculating the scouring and silting of the power station channel is still constant equation of unsteady drifting and the equation of flow motion because

BaiShakou tide power station has no evident saline water wedge and diversity-gravity-flow. The calculation is based on the limited difference method. At first, the calculation program is written in FORTRAN-77 programming language. The calculation of the water power factors of every section of the course is obtained under the different flow rate and tide difference. Then the sand constant equation for tide flow (including the storm) with feature of changeable suspended sand is adopted. That is the sand constant equation, which considers the biggest tide emerged later than emergence of the biggest sand content and smallest sand content emerged later than the emergence of the rest-flow-period. This equation cannot be solved by direct integration. The solution, every section amount of sand content in different period can be obtained with an approximate difference algorithm of every water power factor known above, each section input and output of sand under different condition of tide arising and falling period can be calculated according to the essential equation for tide scouring and silting. The conclusion, according to the computer result, is the momentum of the generation tail water and the flow speed of the falling tide cannot scour away the quantity of silt at the bank and the gate of tail water channel during the period of the stormy tide, especially by the spring tide accompanied by big wind. In fact it is true. For example, the two meteorological quake aroused typhoon in July. 1973, and in Sept. 1985, whose height of wave is 2.66m added 7000m^3 sand and produced sand-drift.

1.3 Mechanical sand proof methods

This kind of experiment has been done for many times. Besides, mud-digging ships, small tugs with mechanical harrow, single-hydraulic giants and scattered hydraulic giants are also used to disturb and dredge silt, and good results are obtained. Most of the sediment can be brought back to sea along tide and generation tail water when this method is taken during the drainage period of ebb generation.

1.4 Engineering facilities

Many kinds of comparisons have been made for the designs of engineering facilities. Two reasons lead to the worsening of the silt which is increased by 1700m^3 in tail water channel in usual years, and the stability of the base tunnel under floodgate is also threatened. One is that on arrangement the eastern sand proof dam in BaiShakou Power Station doesn't accord with the general principle of sea bank engineering management, that is, "making the best use of all sorts of destroying force in nature and reducing the destroying force per beach line to the minimum to control the sea-bank effectively and lower the cost"; The other is the western sand proof dam, 80m long, built in 1984, which should not have been built. It is necessary to demolish the western dam. But this dam is a good fishing vessel wharf. To detente the contradiction, the eastern dam need to be extended. According to the data on a large amount of indoors models of harbor and wharf sea-bank engineering, and on engineering on the field, the eastern dam is a spur dam, and the intersection angle of 149° between the dam axle and the prevailing wave direction in the area should be 100–110° . Therefore to extend the existing eastern dam, turning 30° to the south is surely necessary. With its length L=0.5BW (BW is the distance from water edge to the broken wave point), a hook-shaped dam is built. This not only avoids the occurring of the whirling fluid caused by the spur dam head which brings sediment into tail water channel, but also prevents sand from being carried along the bank to tail water channel by the 115° –150° sea wave.

1.5 Biological measures

Aiming at the silt features out of the mouth gate of the power station, we take biological measures, coordinating with engineering facilities. A large area of plants was planted on the big complex sand dam which is 3km in the east of the eastern sand proof dam. It is divided into three parts in different levels: high, middle and low. On the 1.0–2.0m low beach and dam field, spar ting anglica is planted. This kind of plant is flood-resist, slat-resist, and growing fast. On the 2.5m meddling beach (the supposed level is 1.55m), reed is planted. On the high beach, trees are planted. In addition, west to the sea entrance of the newly built BaiShakou mouth, a short hook-shaped dam has been built as a barrier. Spar ting anglica in the low beach and dam fields not only prevents sediment from being washed away by wave and wind, but also provides feed for cow and sheep, and bait for fish. Besides, it accelerates the growing period of reed in the middle beach, which is used as building materials and fuel, and forms a green scenery environment together with the dense trees on the high beach. Such kind of engineering facilities and environment protection (biological measures) coordinates in harmony, obstructing the sediment of BaiShakou River at the sea entrance of the new river route. The sediment is silted up far away from the tide power station. The goal is reached that extending the service life of the power station without influencing the unimpeded of the generation tail water channel and tidewater filling the reservoir. Obviously, engineering facilities and biological environment protection methods ring the best in each other.

2 ANALYSIS OF MUD AND SAND DEPOSITION AT DAGONG BAN TIDAL POWER STATION

2.1 A Survey of the project

Dogong Ban lies in Fujian Province in China, which was built in 1982. The project includes the sea bank as long as 5,676m, and two water gates, one has 8 holes and the other has 5 holes, each of which is 5 meters wide. All of them are linked by the thirteen separate islands and enclosed to one reservoir. The area of the reservoir is 2753.3 hectares while its volume at average tide level is 7650 m^3. The power station's tidal range is 8.16 m at most, which is comparable to that of the world known Qiantang River tide. The annual output of electric power can be 190 million kWh. And yet this power station can be benefited from aquatic products, tourism and so on. All of these above require that the reservoir keep silt-laden for a long time.

2.2 Tests on sedimentation of dagong ban reservoir

The diameter of the Dagong Ban reservoir's silt particles is mostly about 0.002–0.005 mm. It is fine silt, sediment load and the starting flow speed is quite slow, about 0.4-0.9 m/s. By the experiment of Dagong Ban reservoir's spring, middle, neap tide. We conclude that the water level returns to the normal after the tides, and the inlet and outlet water volume reach equilibrium. So neap tide's ebb and flow is 0.08 kg/m^3 and 0.079 kg/m^3. The middle tide's is 0.116 kg/m^3; spring tide is 0.102 kg/m^3 and 0.116 kg/m^3. The neap tide's sediment charge into and out from the reservoir is almost in balance, yet in middle and spring tide sediment charge at falling is more than that at rising. On average it takes Dagong Ban reservoir 6 hours and 14 minutes to rise, while 6 hours and 11 minutes to ebb. In this case, if the ebb and flow volume is equal, the water level and water-carrying sectional area will influence the in and out water speed as well as the sand-carrying power. When the middle tide is rising, the average water level is 0.98 m at upper reaches and 0.41 m at lower reaches. When it is falling the average water level reaches-0.31m and -0.43m. That means the water level at rising is higher than that at falling. So do spring and neap tides. Therefore the flow speed at falling is faster than that at rising. Accordingly, the sediment charge at rising is smaller than that at falling.

The unequal sediment charge at ebb and flow affects the reservoir's input and output sand. In the neap tide the volume of sand is 1,390 tons input and 2,321 to output, in the middle tide the volume is 2,073 tons input and 2,331 tons output. Judging from this, the volume of sand in spring and middle tide is more than that in neap tide. In addition, the output in spring and middle tide is larger than the input while the input and output sand in neap tide is almost in balance.

3 COMPREHENSIVE ADMINISTERING METHODS ON THE TIDAL POWER STATION’S DEPOSITION OF MUD AND SAND

To control the tidal power station is a comprehensive project. There is no problem starting with an overall engineering, From a systematic analysis point of view, the concrete features as geographic position of the power station, hydrological condition and the situation around must be considered. After a deep research on theory and a long period of practice, to control the tidal power station’s deposition of mud and sand, the following effective measures can be taken:

3.1 Rationally arrange the key position

A Rational arrangement of the key position is a useful way to prevent the tidal power station’s sand and mud from silting up. The inlet and outlet of the power station should be unobstructed, and an appropriate position is necessary.

The Jiangxia tidal power station in Zhejiang Province is the first power station in China which has one reservoir and bas powered in two directions. It was accomplished in May 1980. The capacity of reservoir is 2.75 million m^3, the tidal range is 8.39m at most and 5.08m on an average. The key dam of the power station is 670m long, 15.5m high. The power production is 3200kw. Between the dam and the station building there is a releasing gate which has 5 holes, each of which is 3m wide and 4m high. Because the inlet of the power station lies in the main stream of the sea tide and the stream flow is quite smooth, so that there is no deposition of sand and mud, though it has been operated for many years.

On the contrary, another power station in Zhejiang Province, Haishan tidal power station, generates power by means of two reservoirs and in one direction. The inlet gate was set up at one projecting beach on a sea island. The station was placed at the link-up of the high and low reservoirs. The water outlet gate was set up at the southeast of the low reservoir. This power station was completed and put to use in 1972. It’s power production is 150kw. The area of the upper reservoir is 22.9 hectares and 0.8 hectares at lower reservoir. The average tidal range is 4.91m. The mud and sand conditions of this power station is similar to that of Jiangxia power station. Yet its inlet was placed at the shallow shoal on projecting shore, where the two streams converge, carrying more sand

and mud, more easily to be silted up. So when this power station is in operation, its sedimentation is so serious that it has silted up 63cm during eight years.

3.2 Choose proper operating pattern

There are many causes of mud and sand movement. But the main cause is the stream motive force, it is the power with which the stream carries sand. As mentioned above, according to the tests on sedimentation of Dagong Ban power station, the average flow speed at falling is faster than that at rising. So the sand output at falling is more than the sand input at rising. During the power plant operation, the input and output can also be rationally of the reservoir's water controlled by man.

When choosing the operating pattern of a power station, what we should consider is not to keep the mud and sand in the reservoir for too long a time. Jiangxia tidal power station has been running for a long time without deposition. This is not only because of the rational arrangement of the key positions, but also because of the two-way operating pattern of generation. There are 1.5 hours between flow power and silt down. But the Haishan tidal power station is in reverse, the stream having flowed into the reservoir, except the main stream, most stream in the reservoir flow quite slowly, thus causes the mud and sand to silt down. After accumulating over a long period the sedimentation of reservoir put an end to the power station.

3.3 Take necessary engineering measures

According to the different characteristics of engineering, there are many ways to be chosen. If the sediment charge of the input stream is very large, we can build a dam to hold back sand at the upper, or consider letting the river flow in another way. If the sediment charge of the tide is very large, we may also build a dam to hold back sand. But to deeply solve the sediment problem of the reservoir and tail bay of the power station stream, we may set up a sand blasting gate, when rising, open the gate and let water in, while when the water level rang is at the maximum at ebb, output water will carry away the deposited silt at the bottom of the reservoir. For example, the northern branch tidal station in Yangtse River mouth whose total power production is 0.7million K.W, makes good use of the Yangtse River's large discharge to blast off the deposited mud and sand by sand blasting gate, although it's sediment charge is so large that it can get to 3.5 kg/m^3 in spring tide. Another example, as mentioned above, the BaiShakou tidal power station in Shandong Province in China, it's deposition was rather serious at early stage of operating while later the project measures mentioned above were taken, and then very good result has been achieved.

3.4 Choosing effective mechanical way

We may use mechanical ways to start the deposition in reservoir at ebb so as to carry the mud and sand away. One of the effective ways is to use harrow to start and clear sand. That is: drag the sand harrow by ship at falling tide, start the sand at the bottom of the reservoir and carry it away, taking advantage of the ebb. In addition, we can use air pump to start the sediments again and clear it at ebb.

3.5 Take biological measures

If the water and erosion of soil in the river basin run off obviously, and the sediment charge of stream is quite large, we can plant some suitable trees so as not only to reduce the sediment charge but also to beautify the environment and get comprehensive economic benefits. The above measures have long been practiced in the project and achieved sound effects.

A good many of tidal energy resources are reserved along the coast of China. There are tremendous potentialities to develop tidal power plants. But the problem of deposited silt should first be solved. If the measures mentioned above can be further spread in the projects, we will open up a new way to make full use of ocean resources, both at home and abroad.

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