SPECIFIC FEATURES OF TIDAL POWER PLANTS

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Contents

Summary

This chapter deals with the specific features of tidal power plants. TPPs in the world power industry significantly differ from HPPs on the rivers mainly by their construction in a tidal sea basin (tidal barrage separates a basin from the sea) and from the point of view of electrochemical and biological corrosion, since highly aggressive seawater with ocean salinity affects TPP structures. All these conditions suppose rather different approach to TPP designing, construction and operation as compared to HPP, especially concerning site selection, specific features in determination of capacity and operation of TPPs in power systems.

The difference between TPPs and HPPs manifests first of all in construction technologies. The caisson method, tested in Russia, enables decreasing costs by 33-42 % as compared to traditional method.

The important aspect of TPP construction is the necessity to use of durable construction materials (for the whole estimated service life) and protect them from corrosion and biological fouling (for example, at the Kislaya Guba TPP corrosion of unprotected metal results in 1 mm per year and biological fouling in the penstock amounts to 230 kg per m^2.

A major problem during operation of TPPs in the North is their protection from ice effects (for example, at the site of the Mezen TPP the height of ice hummocks reaches 7 m and icing of structures is 6 m thick).

However all these complicated problems with TPPs have been generally solved by the present time and their definite elements are being improved.

The most complicated problem with TPPs was in provision of large TPPs with hundreds of units (the head at TPP is rather small, but there is an unlimited sea water flow as compared to HPPs) and all the turbine works in the world would not be able to provide TPPs with the required quantity of units. However, this problem has also been solved by elaboration in Russia technologically simple and cheap orthogonal unit, manufacturing of which can be accomplished in large quantities at any mechanical works.

1. Specific Features of Site Selection

The economic viability of TPPs for solution of energy and environmental problems for countries and regions can be justified, as it will be shown below, only when the positive qualities of tidal energy in power systems are used.

If conditions are favorable, not only small TPPs, but micro-tidal power plants may prove to be not only quite efficient but even preferable as, e.g., in the China.

Taking these above considerations into account, it may be said that the real importance of tidal power is through its utilization in large capacity energy systems which make use of TPPs positive properties (constant average monthly energy output during the season and the multi-year period) in order to improve the performance of the system containing along with TPP coal-fired thermal and nuclear power plants in large power grids.

What is the lower power threshold for large-scale economic TPPs of regional importance?

Evidently, there exists a certain optimum relationship between the basin area and the barrage length, which allows the generating units and sluices to be built into the given barrage so that they will provide a high degree of utilization of the basin energy potential and there will be no need to construct embankments. However it should be borne in mind that an embankment, provided it is not very wide, accounts for a relatively small fraction of the total construction cost (Tugur TPP, 11%), and there is no need to choose a barrage site which excludes the construction of embankments. An example of this is the Southern site of the Penzhinskaya TPP wherein the S/L ratio (see Table 1) is an order of magnitude greater than for many projects being designed.

Country, TPP	A_m, m	S, km^2	L, km	S/L. km	E/S, GWh per km^2	E/L, GWh per km	N/L, MW per km
Russia							
Mezen	5.66	2640	85.6	30.8	15.9	490	178
Penzhinskaya:							
Southern site	6.2	20530	72	285	9.3	2639	1200
Northern site	6.2	6788	32.3	210	10.4	2190	664
Tugur	5.38	1080	17.6	61.5	15.0	920	386
Kolskaya	2.36	5.57	1.2	4.7	3.76	17.4	34
Kislaya Guba	2.3	1.1	0.032	34.3	0.91	31.25	12.5
France							
Cotentin-Centre	8	200	69	2.9	26.5	770	209
Rance	8.55	22	0.8	27.6	22.7	625	300

UK							
Severn	8.3	480	16	30	35.4	1062.5	540
Mersey	6.5	60	1.2	50	23.1	1158.3	583
Canada							
Cumberland	9.8	86	5	17.2	40	685	230
Cobequid	11.8	264	10	26.4	44.5	1177	403
Annapolis	6.4	15	0.45	33.3	2.0	67	40
USA							
Passamaquoddy	5.5	120		-	17.5	-	-
Half-Moon Cove	5.5	3.2	0.336	655	0.1	95	35.7
Argentina							
San Jose	5.95	780	7.5	104	23.1	2400	933
Golfo Nuevo	3.66	2200	-		10		
Korea							
Chonsu bay	-	192	5	38.4	-	-	92
Asan bay	6.1	100	2.2	45.4	16.0	730	334
Garolim bay	4.72	50	2.0	25	16.8	420	200
Australia							
Secure	5.6	130	1.2	108	12.3	1333	475
Walcott	5.6	264	2.5	106	12.5	1320	700

Table 1: TPP parameters versus barrage length and basin area (collected by L. Bernshtein)

In a bay of area sufficient to form a TPP basin a site with the depth permitting location of the required number of generating sets will be the most advantageous one as it allows utilization of the basin energy potential without underwater excavation.

Thus it is evident that while selecting the TPP barrage sites, prime attention should be given to sites with the maximum tidal range since the amount of the energy generated and the energy cost depend on the square of the range.

2. Specific Features of Determination of TPP Capacity and Output

After the choice of one or, usually, several barrage sites for the TPP under design, the barrages in question must be evaluated in terms of their efficiency and compared with other alternatives of power supply. To this end, first of all, it is necessary to define roughly the power capacity and energy output that can be obtained at each given barrage site.

The graphical method proposed by L.B. Bernshtein is based on defining the basin regulation regime, i.e. the principle of emptying (or filling) the storage. It is possible to solve the regulation problem only for one mean tidal range and then to apply the solution obtained, with consideration for the tidal factors, to cover the whole of the representative series of the lunar month and year. The formula of the power engineering energy potential is determined by the expression

$$E = 0.67 \times 10^{6} A_{\mathrm{m}}^{2} S \qquad (1)$$

Therefore, the power engineering energy potential of the basin of the TPP in question is 1/3 the gross one (see *Tidal Energy*), and also is proportional to the basin water area and the square of the mean tidal range.

To determine the TPP power at any tidal range, use may be made of the following formula (L.B.Bernshtein):

$$N = 150A^2S \tag{2}$$

Using the above formulae, the TPP power graph may be treated as typical in the calculations to obtain the maximum output.

3. Non-Traditional Technologies of TPP Erection

According to traditional classical method the HPP is constructed in the river channel in the dry conditions behind cofferdams and includes a massive structure of powerhouse with vertical shaft turbine units. For seashore conditions, construction of cofferdams in the sea is extremely complicated and expensive. For example, construction of the cofferdam at the Rance TPP in France threatened implementation of the whole project and doubled the price of the whole TPP. In 1959 for the first time in the practice of power construction the pilot caisson Kislaya Guba TPP was constructed in Russia by L.Bernshtein.

The powerhouse with all the equipment was constructed in the dry in Murmansk and delivered by push boats by sea for 100 km to the site of permanent operation, where by water ballast it was lowered on the prepared foundation. This revolutionary approach permitted to avoid the necessity to construct facilities at the site, camp for construction personnel, transport facilities, as a result of which the construction time was reduced by half and cost of construction by one third. At present the caisson method of construction is used in all modern designs of large TPPs and also for construction of large reinforced concrete platforms for extraction of hydrocarbon resources on the world shelf.

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Biographical Sketch

Igor N Usachev was born in July 4, 1932, Moscow, USSR

1957 – Graduated from the Moscow Power Engineering Institute.

1973 – Candidate of Technical Sciences (Thesis Investigations of very high frost concrete and fine-wall reinforced concrete hydraulic structures at the North.

1957 – up to now – engineer, chief engineer of the projects, Director of Laboratory and Head of Department, Design, Survey and Scientific Research Institute «Hydroproject».

1963-1984 – Chief of Group on Working Designing and studies of Hydroproject, Kislaya Guba tidal power plant

Author of more than 400 scientific papers and 7 monographs.

Main activities: mastering tidal energy; introduction of floating techniques in erecting of hydropower projects; development of long-living marine construction materials; electro-chemical and biological corrosion protection.

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