CALCULATION AND RESEARCH FOR TRANSIENT FLOWS IN POWER STATION OF BULB TUBULAR TYPE TURBINE AFTER LOAD REJECTION

CHEN YUN-LIANG, WU CHAO, JU XIAO-MING, YE MAO

The State Key Laboratory of Hydraulics and Mountain River Engineering,
Sichuan Univ., Chengdu 610065, China
(Tel: +028-85401144, Fax: +028-85405148, e-mail: liangyunchen@163.com)

The electric power demand increases fast on economically advanced coastal region in China. The available medial or high head hydraulic resource is little on the region, but the low-head hydraulic resource is abundant. It is a fine way to utilize bulb tubular type turbine for developing the hydraulic resource of low head. The structure of the station is compact, the project is small and the construction period is short, comparing with the station of medial or high head and the vertical axis-flow station of low head. And it is fit for complex development and utilization of the hydraulic resource of low head. So power station of bulb tubular type turbine progresses very fast now. But during the station transient flows, accidents happen frequently. So the research for transient flows in the station is very valuable for safe operation.

Sha (1980) pointed out that hydraulics and mechanics should be analyzed together in researching transient flows in power station of bulb tubular type turbine. And he thought that hydraulic transients not only existed in head conduit, but also in upstream and downstream open channel. Chen (1984) and Wang (1983) pointed out that when station load were changed sharply, it would cause unsteady flows in approach and tail channel. School of Hydraulic Engineering, Hehai Univ. (1995) researched transient flows in Baishiyao Tubular Station through assuming that water levels of draft tube outlet and penstock intake were constant. It is feasible to ignore the effect of unsteady flows in upstream and downstream open channel for station of higher head. But the head of bulb tubular type turbine is lower and discharge is larger. When station load are all rejected at the same time, discharge may change widely. It may result in violent water fluctuation in upstream and downstream open channel. In the actual project layout, the river in front of dam is wider. So the impounding reservoir in upstream open channel is formed, which can buffer water fluctuation. Therefore it is proper to assume that the water level of penstock intake is constant. But downstream open channel is often narrow. When station load are all rejected at the same time, water fluctuation in it is violent. It can cause head changing widely. In this case unsteady flow in downstream open channel must be analyzed in order to simulate transient flows more completely.

Therefore, this paper is just about the unified calculation and research for the transient flows in the units and downstream open channel after load rejection. The cooperative motion law of wicket gates and blades is losing after load rejection. So when the unit's boundary equations are founded, a series of characteristic curves of constant blade angles are adopted to simulate unit's characteristics. The boundary equations between draft tube outlet and downstream open channel inlet are deduced from the characteristic equations and corresponding boundary conditions. The diffusion method is used to solve the equations of middle cross sections of downstream open channel.

Table.1 shows the comparison of transient qualities, in which A and B denote two cases: the water level of draft tube outlet is constant and fluctuant. It shows:

Table 1. The comparison of the transient qualities

Transient Qualities	The Maximal Rising Rate of Rotate Speed	The Maximal Water Pressure in front of Wicket Gates	The Maximal Positive Axial Hydraulic Thrust	The Maximal Opposite Axia Hydraulic Thrust	The Minimal Water Pressure at Draft Tube Intake
A	0.372	19.03m	816.596KN	-216.138KN	3.39m
B	0.383	19.83m	816.596KN	-214.078KN	2.35m
The Relative Differences	3%	4.2%	0	-0.9%	-31%

(1) The maximal positive and opposite axial hydraulic thrust are little affected by unsteady flow in downstream open channel. (2) The maximal rising rate of rotate speed and the maximal water pressure in front of wicket gates increase 3% and 4.2% comparing with case A. After load rejection, discharge reduces due to wicket gates closed. It can cause that the water level of draft tube outlet descends. So in this course, the water head is higher in case B than in case A. It results that the maximal rising rate of rotate speed and the maximal water pressure in front of wicket gates are larger in case B. (3) The minimal water pressure at draft tube intake reduces 31%. As the water level of draft tube outlet descends after load rejection, the minimal water pressure at draft tube intake is smaller in case B than in case A.

The head of bulb tubular type turbine is low, and discharge is large. When all load are rejected, discharge will change widely. It will result in violent water fluctuation in downstream open channel and head great variety. The effect on transient qualities must be thought. The calculation and research for transient flows in units and downstream open channel are just for this factor. Through the unified calculation and analysis of hydraulics and mechanics, pressure flow and unconfined flow, the transient flows in hydroelectric station are simulated completely. The results can direct safe operation of the bulb tubular type turbine and navigation in downstream open channel. In addition, when station work condition or load is changed, transient exists in electric installations too. So it is necessary to analyze hydraulics, mechanics and electricity together, which will be further researched in future.

REFERENCES

Sha, X.L. (1980). Hydroelectric Station of Tubular Type, Hydraulic Eng. Publishing Company of China. (in Chinese).

Chen, S.Y. (1984). "Iterative Bisection Method for Transient Flow Pattern of River Unsteady Flow." Journal of Hydraulic Engineering, (5), 51-59. (in Chinese).

Wang, D.B. (1983). "Calculation of Channel Unsteady Flow for Water Power Station Design." Journal of Hydraulic Engineering, (5), 33-40. (in Chinese).