ANALYSIS ON OSCILLATION AND STRUCTURAL OPTIMIZATION OF STEPPED LOW-PRESSURE WATER TRANSFER PROJECT

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The stepped low-pressure water transfer project is a new type gravity water transfer system that consists of separated pressure pipes (water transfer units), which are connected in series by surge wells with overflow weir in them. Because the altitude of overflow weir crest in each surge well is higher than the altitude of crest of upstream pipe that is connected with this surge well, therefore when the water transfer system stops running the whole pipeline is still in pressure. This kind of structure can adjust water level naturally and dispel the surplus pressure, but as hydraulic transients process takes place in water transfer system, periodic hydraulic oscillation will occur in water transfer units and it may enlarges piecemeal while propagating to the low reaches and come into being severe oscillation at the end of water transfer system, which will make negative effects on the project. According to the hydraulic characteristic of stepped low-pressure water transfer project, the numerical model is established and program is made to simulate unsteady flow for the project in this paper.

Firstly, the origin cause of water level oscillation in the water transfer system is analyzed. Through analysis on the flow processes of the two neighboring water transfer units, it is proved that hydraulic oscillation is due to the outer-sync of flow processes in the two neighboring water transfer units that results from the pipe resistance to water. When the flux of the upstream water transfer unit is more than the flux of downstream unit, water will accumulate, which can cause the water level to rise in the incline shaft; When the flux of the upstream water transfer unit is less than the flux of downstream unit, water in the incline shaft will compensate the flow, which can cause the surface of water in the incline shaft to fall. Therefore water level in the incline shaft will oscillate continually.

Next the hydraulic oscillation equation of this structure is derived from locomotion differential equation of unsteady flow, and then hydraulic natural frequencies equation is given. By comparison the hydraulic oscillation equation of this structure is similar to oscillation equation of U-shape tube in form. The equilibration state of the hydraulic oscillation is the state of steady flow. If there is quiescent water in pipeline, the stream will not flow to the forward direction all the time, and that is the water height on the weir will not maintain invariable, which will cause the restoring force to increase. When stepped low-pressure water transfer project stops running, the flux turns into zero gradually and downstream water level is lower than the altitude of the weir crest. At this moment hydraulic oscillation characteristics of this water transfer system and U-shape tube are self-same.

Then a research will be made on characteristic of hydraulic oscillation propagating between two neighboring units with the same length and diameter. When the frequencies of the two neighboring water transfer units are close, the amplitude of hydraulic oscillation

will enlarge fast while propagating to lower reaches. With the frequencies of the two water-transfer units staggering each other gradually, the amplitude begins to diminish gradually. The calculation result has proved that the hydraulic resonance exists indeed. In the course of propagating hydraulic oscillation is related with the natural oscillation frequency of downstream neighboring unit. When the oscillation frequencies of the two neighboring units are close, the resonance will arise with oscillation propagating to lower reaches.

Finally the measures to control hydraulic oscillation and avoid hydraulic resonance are suggested in this paper. Staggering the oscillatory frequency of neighboring water transfer units can avoid hydraulic resonance and decline the enlargement of water level oscillatory while propagating to the low reaches. Changing diameter of incline shaft at the intake or adjust the length of pipeline of some water transfer units can effectively Stagger the oscillatory frequency of neighboring water transfer units and avoid the hydraulic resonance.

Keywords: Stepped low-pressure water transfer project; Hydraulic oscillation; Resonance; Hydraulic transients; U-shape tube; Incline shaft