M.Sc THESIS

NUMERICAL MODELLING FOR SENSITIVITY ANALYSIS OF WATER HAMMER IN PENSTOCK

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ABSTRACT

Water hammer is a transient flow which is produced because of sudden velocity changes in penstock of hydropower plant. Thus, this phenomenon may lead to initiates strong pressure wave in penstock. The developed pressure wave produces large stresses inside penstock pipe; if the pressure exceeds the design pressure of penstock, the result would be collapse of pipe.

Sensitivity analyses are very important to understand the pressure fluctuations in penstock and to make its design safer. In this study, governing equations of water hammer i.e. continuity and momentum equations were numerically solved and simulated by developing a computer program in "Visual Basic" environment. The developed software can perform iterative solution of the numerical equations in small amount of time as compared to hand calculations. The fluctuations in positive and negative pressures were calculated by varying hydraulic design parameters (such as diameter and length of penstock; and wave velocity) one by one considering the rest of parameters as constant. The program employs both, method of characteristic (MOC) and Method of Implicit (MOI) for numerical solution. Moreover, the program is also capable to compare the results of both methods.

Depending upon the sensitivity of the water hammer phenomenon, it is obligatory to prepare adequate and cost effective design of penstock to avoid any cavitations.

The study provides quick, handsome and tested analysis of results against water hammer phenomena and optimum design of penstock. In addition, it shows, by reducing the penstock pipe diameter and wave velocity and increasing pipe length, the maximum pressure head increased and the minimum pressure head decreased. It helps the designers to understand the effect of water hammer phenomenon and critical locations where remedial measure may be needed.

The software developed in this study was also applied to two hydropower projects in northern area of Pakistan i.e. Kyal Khwar hydropower plant and Satpara hydropower plant. The developed program showed good agreement with the original data prepared by the commercial software used by the consultant of Kyal Khwar hydropower plant and Satpara hydropower plant.

Kywords: Water Hammer, Transient Flow, Valve, Surge Wave, Penstock Pipe, Visual Basic