



Optimum Design of Penstock for Hydro Projects

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Abstract: Penstock, a closed conduit, is an important component of hydropower projects. Various methods are available for optimum design of penstock. These methods are either based on empirical relations or derived analytically by optimizing the friction loss in the penstock. These formulae produce different values of penstock diameter for same site. In this study, formulae available for penstock design have been compared to review their suitability. A new method has been developed for the optimum design of penstock based on minimizing the total head loss comprising of friction and other losses. By using new developed method, diameter and annual cost of penstocks for few Hydro Electric plants of varying capacity have been worked out and reduction in annual cost of penstocks have been found in comparison to penstock cost for these projects.

Keywords: Friction Losses, Total Head Losses, Annualized Penstock Cost, Optimum Diameter of Penstock

1. Introduction

Hydropower, a renewable and mature energy source utilizes water from higher to lower altitude to generate power. Hydro Power is one of the proven, predictable and cost effective sources of renewable energy. Hydropower system (Fig 1) comprises of hydro source, diversion/storage system, water conductor system (channel/tunnel/penstock), power house building, generating and control equipment. Penstock is a conduit or tunnel connecting a reservoir/forebay to hydro turbine housed in powerhouse building for power generation. It withstands the hydraulic pressure of water under static as well as dynamic condition. It contains the closing devices (gates /valves) at the starting (just after reservoir/forebay) and at the tail end just before turbine to control the flow in the penstock. The penstock material may be mild steel, glass reinforced plastic (GRP), reinforced cement concrete (RCC), wood stave, cast iron and high density polyethylene (HDPE) etc. However, in the most of the cases, mild steel has been used for penstock since long due to wider applicability and availability. The penstock cost contributes an appreciable percentage towards the total civil works cost of the hydroelectric project. By optimizing the penstock diameter, maximum energy generation can be obtained at minimum cost.

The aim of present study is to develop the new relation for the optimum design of penstock by considering all types of losses in the penstock.

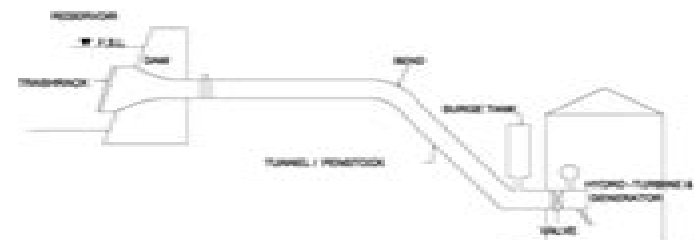


Fig. 1. Penstock and Hydropower system schematic layout.

2. Relations Available for Optimized Design of Penstock

Various researchers have proposed the methodology and relations for the optimum design of penstock. These relations are either empirical relations developed by analyzing and correlating statistical data of existing/installed projects designed as per past practice or derived analytically by minimizing annual penstock cost considering friction loss. The available analytical relations considered only friction loss whereas in addition to friction loss, there are other losses such as losses at specials (bends, transition piece, tri/bifurcation etc.), losses at valves and inlet which are not

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