Effect of runner blade numbers on inter blade vortices of Francis turbine under best efficiency loading.

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Abstract. The focus of this study is on inter-blade vortices generated due to the change in number of blades in high head Francis turbine along with their characterization, relationship with rotor stator interaction and pressure fluctuations along the blades of the runner. Selection of proper number of blades during the design stage is very crucial as it dictates performance of turbine at all possible operating condition including the flexibility requirement of hydro energy in a hybrid energy system. The domain for this study was taken from Francis-99 with the discard of splitters in the runner. Eight different cases were formulated, each having different number of blades with minimum of 14 numbers and maximum of 21 numbers. It is observed that inter-blade vortex has a significant effect on RSI thereby causing hydraulic losses and vibration. Moreover, the inlet inter blade vortex are more prominent for cases with lower number of runner blades and vortices generated at inlet which are attached to suction side of the shroud travels all the way to the trailing edge with a major disturbance in the flow downstream.

1. Introduction

Ample of research have been carried out to study the inter blade vortex due to the change in the loading conditions along with its effect on both the hydraulic performance and fatigue life of runner. Numerical study of channel vortices in a Francis runner was carried out by Lingjiu Zhou et. al[1]. Based on the operating condition, vortices were classified into four different types. The pressure fluctuations from the upstream to the downstream of the runner at different operating conditions is highly influenced by the inter blade vortex[2] [3]. In addition, the fluctuations are of different frequency and amplitude is different for different span of blade[3]. It has been experimentally observed that with the decrease in the flow and the head, the inter-blade vortex becomes stronger and results in pressure fluctuations both in vaneless space and draft tube [4]. It has been experimentally observed that with the decrease in the flow and the head, the inter-blade vortex becomes stronger and results in pressure fluctuations both in vaneless space and draft tube [5]. The main losses in the runner under part load operation are from inter-blade vortex which may account more than 24% of the total losses [6]. The formation and strength of inter blade vortex are significantly affected by blockage factor of runner. Increasing the blockage effect of the runner blade based on thickness decreased the inter-blade vortex strength and size at same operating condition [7]. Further, there is reduce in the unsteady pressure with significantly higher blockage ratio[8]. However, the hydraulic performance along with the inter flow characteristics has adverse effect when the runner is operated in BEP and full load condition[9].

Although lot of research are directed towards the inter-blade vortex and its effect on the hydraulic performance of the runner at different operating condition. The consequence of number of blades on the inter blade vortices and its effect on the performance of the turbine have not been explored. Selection of right number of blades for a smooth operation of the turbine in any loading condition is necessary for