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Numerical Modeling of A Francis Turbine Draft Tube Under Full and Partial Loads

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Abstract – This study is related with numerical modeling of a Francis turbine draft tube. In order to reveal this relationship, a real Francis turbine model test results are used as inputs of the computational fluid dynamics (CFD) study. Firstly, the flow in divergent channels at different apical angles and with varying uniform tangential velocity is considered in order to simplify the geometry and boundary conditions. Afterwards, tangential velocity profile is defined by means of radial coordinate (r), characteristic vortex radius (R) and angular velocity (Ω); and it is interpreted as a tangential velocity boundary condition by the help of user defined functions (UDF's). Finally, the numerical modeling of draft tube with elbow is analyzed and again UDF's are used for tangential velocity component. The draft tube modeling with CFD is carried out both in full and 50% partial loads. As a result, it is clearly seen that the flow is much more turbulent at partial load. While there are almost no vortices at 0.02 s^{-1} vorticity intensity at full load, the vortices are quite observable at partial load in same vorticity intensity. Furthermore, the static pressure fluctuations are observed after the elbow of the draft tube at the partial load. While meshing divergent channels, mapped mesh elements are used. RNG k-ε turbulence model is used during the whole CFD simulations.

Keywords – Draft tube, Francis turbine, vortex rope, CFD, partial load, turbulence