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Challenges in Dynamic Pressure and Stress Predictions at No-Load Operation in Hydraulic Turbines

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Abstract

Some of the potentially most damaging continuous operating conditions for hydraulic turbines are the no-load (NL) conditions. At NL conditions the flow passes through the turbine without power generation, but with non-negligible flow rate, and therefore all the potential energy in the flow has to be dissipated. This takes place through a mechanism where the runner channels are partially pumping, thus generating large scale unsteady vortex structures which, by their nature, break down into smaller and smaller vortices until energy dissipation occurs at the smallest scales. This type of flow, dominated by its turbulent character, is inherently difficult to simulate by means of numerical methods since turbulence model and numerical dissipation have a major influence. The resulting dynamic loads on the runner are largely of stochastic nature, exciting a broad band of frequencies and thus, almost always interact with at least one deformation mode. The presented investigations are aimed at predicting the effect of the unsteady NL pressure loads on the fatigue life of a Francis turbine runner. A combination of computational fluid dynamics (CFD) and finite element analysis (FEA) methods has been employed. The results from transient CFD simulations are presented. Comparison of the results with prototype strain gauge measurements at no load conditions shows that the stochastic nature and the approximate range of the dynamic stresses can be predicted.