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Fatigue Strength Analysis of Highly Loaded Pole Endplates

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Abstract

Rotating parts of hydrogenerators are subject to enormous centrifugal forces. Due to the volatility of renewable energy sources and altered market conditions European hydropower plants currently are facing an increased frequency of start-stop cycles. Not only new pumped storage units but also such that were originally designed for annual storage operating mode are now being operated with several start-stop cycles per day. Traditionally, static strength assessment was sufficient to guarantee safe operation over the full service life whereas for the new operating conditions strength assessment has to include fatigue analysis. Large hydrogenerators are usually salient pole type machines. In these machines the highest stress concentrations typically develop in the pole endplates. Therefore the pole endplates are considered the most critical parts in terms of mechanical fatigue. Depending on the rotor design and the type of pole fixation rotor rim or yoke ring might show high stress concentrations as well. For new equipment as well as for rehab projects the fatigue strength analysis is ideally carried out in the initial engineering stage of a customer project - the tender phase - because the choice of materials and steel grades has a big impact on production costs. In this phase a quick and at the same time accurate method is required to find the optimum solution for the individual application. A standardized and fully parameterized analysis process has been developed to fulfill the above needs. The process incorporates an automatized generation of the model for calculation, the FEM calculation routine and based on the stress situations an evaluation of strength utilization over the full service life according to FKM guideline.

The paper highlights the process of fatigue strength assessment of a highly loaded pole endplate of a pumped- storage hydrogenerator. The demonstration of the FEM stress calculation will show the big influence of the strongly orthotropic material properties of the pole winding that adds additional load to the pole endplate. A comprehensive description will be given on how stresses and their gradients will be derived. Finally the application of FKM code will be explained.