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Impact of RAG-induced concrete deformation on side chamber flow and on dynamic loading of a low head Francis turbine

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ABSTRACT

The alkali-silica reaction ("Réaction Alkali-Granulat", or RAG) is a chemical reaction that can occur over time in concrete and can cause cracking and swelling over extended time periods. In hydroelectric turbines, RAG can cause deformation and movements of the stationary components over the course of a unit's lifetime. In turn, these deformations lead to non-uniform flow and pressure distributions in the side passages around the runner, causing a net radial force and cyclical dynamic loads on the runner.

In the context of a rehabilitation project for a low-head Francis turbine, strain measurements on existing units performed by the owner showed significant dynamic loads on the runner at 1x and 2x the rotation frequency. Studies from the owner concluded that these dynamic loads were caused by a RAG-induced deformation of the concrete surrounding the machines, which deformed the shape of the bottom ring and discharge ring from concentric circles to eccentric ellipses over the lifetime of the machine. In addition, the axial displacement of the lower bracket was greater than for the bottom ring, leading to an upwards displacement of the turbine relative to the stationary components.

ANDRITZ included the impact of the foreseen future RAG-induced deformations of the bottom ring and discharge ring during the design of the replacement turbine during this rehabilitation project. We performed steady-state CFD simulations of the full band side passage at full-load condition for both the undeformed and deformed shapes and extracted the pressure distributions around the runner. The maximum RAG-induced dynamic stress amplitude was determined by rotating these pressure distributions around the runner by increments to simulate the spatial variation of the loading for a rotating runner. In turn, this RAG-induced stress was added to other stresses when running the fatigue analysis for the replacement runner.