Pump storage Hydropowerplant Limmern - Hydraulic model tests of the intake structures, lower basin Limmernsee *2007/2008*

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Client: Kraftwerke Linth-Limmern AG (KLL)

Introduction

Today's Linth-Limmern hydropower scheme has an installed capacity of 340 MW. The extension project “Linthal 2015 KW Limmern” (Figure 1) plans a new underground pump storage powerhouse, which will pump water from the lower basin (Limmernsee) into the upper basin (Muttsee) situated 630 meters above. During peak hours, the water can again be used for generating energy. The projected plant will have a capacity of 1000 MW.

Figure 1: Layout of the KW Limmern project

Objectives

The upper (Muttsee) and the lower (Limmernsee) intake structures are two particular elements belonging to the development project mentioned above. The optimal location, orientation, shape and exploitation of these structures were to be examined in hydraulic model tests. Therefore, the following aspects have been analyzed:

- Operability of the intakes, possible auxiliary elements needed for vortices reduction
- Inflow and outflow conditions, head losses
- Qualitative investigations concerning sediment deposits, whirling up and sediment entrainment
- Investigations concerning ice formation and defense
- Mutual influence of the two lower intakes

Physical model

The limits of the physical model were selected in a way that the substantial influences of the topography on the flow conditions can be considered and the model delimitation leads to no substantial influences.

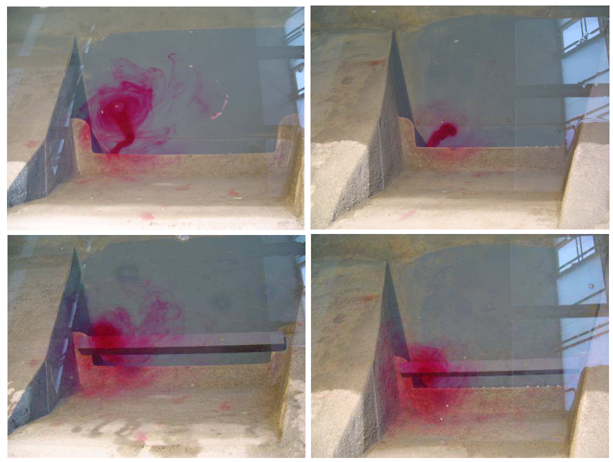
Figure 2: Hydraulic model of the two intakes

In the hydraulic model, scale 1:36 (Figure 2), the vortex formation can be represented adequately and the air entrainment potential (eddy with permeable core) can be estimated correctly.

Results and conclusions

The results of the model tests permitted to draw the following conclusions:

Vortices formation: In order to reduce the vortices formation above the intakes, a crossing beam is recommended to be implemented over each of the two intakes (Figure 3). On one hand these beams act as a direct obstacle for eddies and on the other hand, they provoke an injector effect behind the bar. The optimal efficiency of the beams depends on their size and position above the intakes.



a) *b)*

Figure 3: Vortices formation above the intake structures, without (above) and with the horizontal crossing beam (below) a) eastern intake, b) western intake

Flow conditions in front of the intakes: The flow field is uniformly distributed over the width of the intakes and the entering flow velocities are in a usual range. The water jet flowing out of the structure is unstable and concentrates on only 2/3 of the cross section. This phenomenon causes high flow velocities and reverses currents on the exterior of the intake. The flow distribution can be improved by installing two guidance walls inside the intakes. The energy losses are relatively small both in generating and pumping mode.

Sediment transport: In pumping mode, only very small grains are entrained into the water intake, the erosion zones are limited to the direct proximity of the trash rack. In generating mode, the sediments on the platform in front of the rack are almost completely eroded and transported into the lake. Thus, there should be no sediments entering into the intake under normal exploitation conditions with alternating generating and pumping sequences.

Ice formation and ice defense: When the lake is covered by an ice layer, a minimum water level has to be guaranteed and the thickness of the ice above the intakes must be monitored. These methods allow preventing the blocking of the racks by ice plates. The risk of a blocking due to frazil ice can be reduced by operational and structural measures.