Pump storage Hydropowerplant Limmern - Hydraulic model tests of the intake structures, upper basin Muttsee 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.

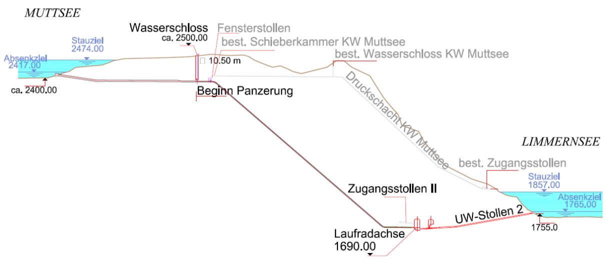


Figure 1: Layout of the KW Limmern project

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

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.

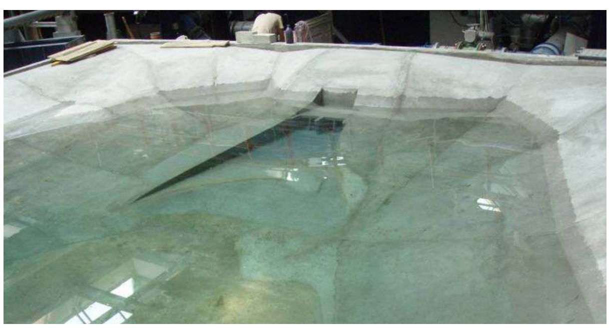


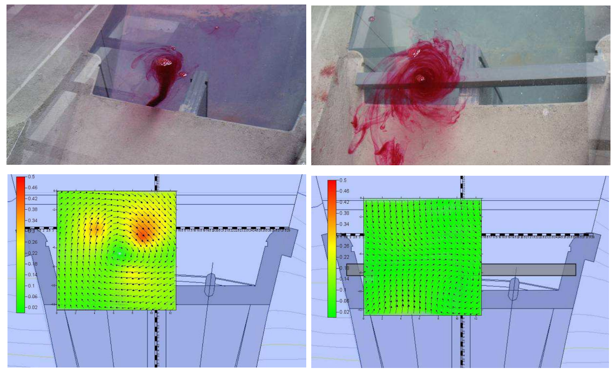
Figure 2: Hydraulic model of the intake

In the hydraulic model, scale 1:42 (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 intake, a crossing beam is recommended to be implemented over the intake (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 intake.



a) b)

Figure 3: Vortices formation above the intake structure (Photos and 2D-ultrasonic velocity field measurements) a) without and b) with the horizontal crossing beam

Flow conditions in front of the intake: The flow field is uniformly distributed over the width of the intake and the flow velocities are low both for entering and out flowing water. The energy losses are relatively small both in generating and pumping mode. These conditions reveal a very adapted hydrodynamic design of the Muttsee intake.

Sediment transport: In generating 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 pumping 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 intake 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.

Numerical calculations: In addition to physical modeling numerical simulations have been carried out with the CFD-solver FLOW-3D® within the frame of a Student project. Thus, the flow conditions in front of the intake and the vortices formation observed in the physical model could be checked and confirmed.