Energy
National Research Programmes 70 and 71

Project

Sediments in high-head hydropower plants

Tiny Particles Threaten Hydroelectric Turbines

Tiny Particles Threaten Hydroelectric Turbines

Despite desanding facilities, the water that drives power plant turbines still contains sediments, causing damage to the infrastructure as well as production losses. Researchers have now optimized these facilities and developed new design guidelines.

Before water can drive turbines, it must pass through desanding facilities: a plant near Saas-Balen in the canton of Valais *Source:* VAW / ETHZ

At a glance

- In the large alpine hydropower plants, production is lost due to abrasion of the turbines by tiny particles in the water.
- Although so-called desanding facilities are designed to remove a large portion of the suspended load present in the water, they are not fully reliable.
- In order to increase the efficiency of desanding facilities, researchers have modelled their flow conditions and developed new guidelines for their design.

Large alpine hydropower plants are the backbone of Swiss electricity production. The Energy Strategy 2050 aims to further increase their efficiency, but small particles in the water, i.e. sediments, stand in the way of this goal. Fine sediments carried by rivers act like sandpaper on the turbines of power plants and obstruct them. This problem is well known and power plants operate desanding facilities designed to reduce the suspended load. These systems consist of elongated basins in which the water flows very slowly, allowing the particles to settle on the bottom. But even the latest generation of these facilities only partially fulfil their purpose. For this reason, turbines require more frequent maintenance work, causing electricity production downtime and financial losses. In Switzerland alone, annual costs are estimated at approximately 6 million Swiss francs.

Die Entsandungsanlage Wysswasser bei Fiesch im Kanton Wallis. VAW / ETH Zurich

Systematic testing

In order to minimise such production losses, the investigators involved in this project used computer models to simulate the flow conditions in desanding facilities, and carried out measurements in three hydroelectric power plants in the canton of Valais. The analyses revealed that a significant part of the sediments pass through the desanding facilities. By way of example, the average particle sedimentation equalled 62 percent in one of the investigated installations and only 16 percent in another one.

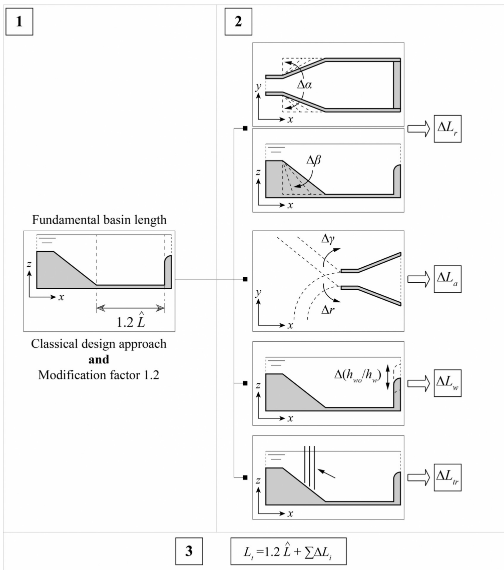
The measurements also served as a basis for the calibration of the three-dimensional computer models which were used to systematically test the impact of the individual design elements such as the opening angle of the basin or the calming rakes in the water. The scientists were for instance able to show that a strong curve in the inlet channel of the structure significantly reduces the efficiency of the desanding facility, as the asymmetrical inflow prevents the water from calming down sufficiently. The simulations revealed that a small to medium curve is acceptable and that a rake can further reduce the negative influence in the transition zone.

Rakes in the basins calm the water flow and contribute to efficient desanding.
VAW / ETHZ

The researchers also studied the impact of the geometry of the basin. They were able to demonstrate that the way in which the canal leading to the basin widens, i.e. whether it widens continuously or abruptly reaches full width, is not a significant factor. The situation is different with respect to the vertical angle, i.e. how the canal deepens: a gentle ramp causes less vortices than a steep wall, which is important for efficient particle separation.

New dimensioning process

However, the simplest way to improve settling performance is to use longer basins in which the water can flow slowly and suspended particles can settle efficiently. But longer basins require more building material and above all a lot of space. This makes them more expensive and it is therefore important to avoid planning basins that are longer than necessary. However, the computer simulations have shown that the classical dimensioning approach is inadequate: the required basin length for satisfactory settling performance is generally underestimated by at least 20 percent. In order to increase the efficiency of the desanding system, the researchers thus recommend multiplying the calculated basic length by a factor of 1.2 during the dimensioning process. Starting from the calculated basic length, the length is then adjusted according to the opening angle of the basin, the arc of the inlet channel and the height of the weir at the end of the basin. The presence or absence of a rake calming the water currents also influences the efficiency of the system. As a result, the engineers obtain the required overall length of the structure.



The basic length of the desanding basin as calculated using the classical design approach should be multiplied by a factor of 1.2. The right column shows the different geometry elements that can be modified, further influencing the required basin length. VAW / ETHZ

Practical implementation

The investigators point out that making the new findings known to all actors in the hydropower industry and the planning companies so that they can be put into practice is not an easy task. In their opinion, knowledge and technology transfer events for electricity companies and planning companies, during which not only theories but also practical examples are presented, are a way of spreading the information. The new design guidelines should by all means be followed when planning new facilities so as to improve the efficiency of the entire power plant.

Produkte aus diesem Projekt

- Assessment of flow field and sediment flux at alpine desanding facilities
  Date of publication: 15.11.18
- Flow and sediment flux characterization at desanding facilities
  Date of publication: 01.01.18
- Design Optimization of Desanding Facilities for Hydropower Schemes
  Date of publication: 17.07.18
- Messungen von Strömungsfeld und suspendierten Sedimenten an Entsandern von Wasserkraftanlagen
  Date of publication: 01.01.18
- Assessment of flow field and sediment flux at alpine desanding facilities
  Date of publication: 01.01.18
- Design optimisation of alpine desanding facilities
  Date of publication: 21.03.17
- How can we deal with sediments to keep hydropower sustainable?
  Date of publication: 16.10.16
- Design Optimization of Alpine Desanding Facilities
  Date of publication: 02.02.18
- Flow field and sediment flux measurements at alpine desanding facilities
  Date of publication: 20.09.16
- Design optimization of alpine desanding facilities (2015)
  Date of publication: 01.01.18
- Design optimization of alpine desanding facilities (2016)
  Date of publication: 01.01.18
- Dealing with sediments at hydropower schemes: design of bypass tunnels and desanding facilities
  Date of publication: 17.10.18
- Neues Bemessungskonzept für Entsanderanlagen an Wasserkraftwerken
  Date of publication: 13.06.20

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Associated projects

Periglacial zones and hydropower

Reservoirs where glaciers once were?

Sustainable floodplain management and hydropower

Flood on demand

All information provided on these pages corresponds to the status of knowledge as of 10.05.2019.