BOOSTING THE DISCHARGE OF A HYDROPOWER PLANT

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1. Introduction

1.1 General

The Opponitz power station on the River Ybbs was built in 1922 - 1924 to supply Vienna with electricity, making it one of the oldest hydroelectric power plants of the Austrian capital.

The power plant Opponitz, which is owned by Wien Energie GmbH, carries water with a free surface over an 11.3 km long tunnel system (diameter ca 2.5 m) from Gießling to Opponitz. There, at the end of the tunnel, is a free-surface surge chamber with overflow, where the transition to the penstock down to the powerhouse takes place (drop height = 115 m).

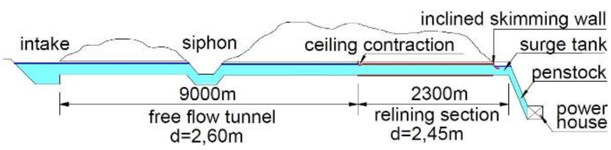

Fig. 1. Sketch of headrace scheme HPP Opponitz.

1.2 Problem

In the course of the renovation of the power plant, the last 2.3 km of tunnels were rehabilitated due to water leaks into the mountain in the so-called "relining" process. Here glass-fibre reinforced plastic (GRP) pipes were drawn into the original tunnel profile and the gap filled. However, due to the reduction in cross-section, which could not be compensated by the smoother tube design, this measure led to a considerable reduction in the maximum turbine quantity of water from the desired 12.7 m^3 / sec to about 11 m^3 / sec.

Subsequently, Wien Energie GmbH commissioned the Institute of Hydraulic Engineering and Water Resources of the Vienna University of Technology to find a possible solution to this problem. The achievable upgrading of the tunnel was to be demonstrated in the form of physical model experiments.

2. Solution

Since a reduction of the flow resistance of the already relatively smooth GRP pipeline was not technically possible, a proposal was developed for the creation of a suction operation in the relined pipe.

In order to achieve this suction operation, it was necessary to ensure that water occupied the full relined cross-section. For this purpose, an inclined skimming wall was installed in the transition to the open cross-section of the surge chamber. Another skimming wall at the beginning of the relined tube was to prevent the further entry of air from the upstream water in the suction mode. Any air still in the tube was to be sucked out by means of a vacuum pump.

3. Model experiments carried out

3.1 Model set up

The model was scaled according to Froude in order to take into account the inertial and gravitational forces. To keep the deviations in the friction losses low, a very large model scale of about 1:16 was adopted, simulating only a 260m long pipe section. As shown in a preliminary experiment on a smaller scale, the suction operation could be verified in the larger model with a shortened tube length.

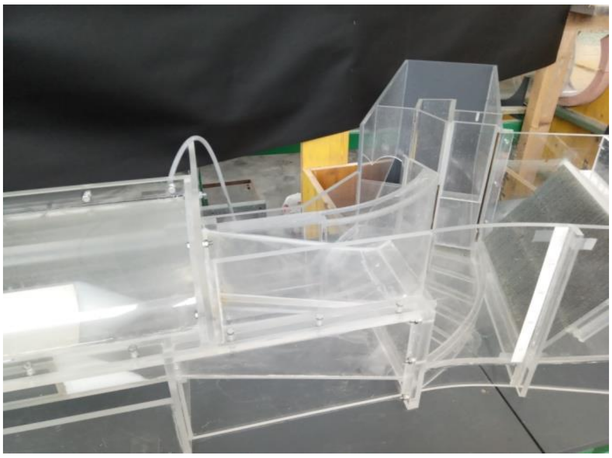

Fig. 2. View of the surge chamber with the inclined skimming wall.

3.2 Data acquisition and measurement technology

The measurement data acquisition and the subsequent analog / digital conversion were carried out with a measuring amplifier "Spider" and the software "Catman" from the company HBM at a measuring rate of 10 Hz. The flow measurement was carried out with a specially calibrated inductive flowmeter from Endress + Hauser (measurement deviation < 0.1%). The pressure or water level measurement was carried out with seven high-precision pressure transducers (measuring accuracy ± 1 mm).

3.3 Experiments performed and lessons learned

The aim of the experiments was to examine both the proposed solution for normal power plant operation and an emergency shutdown of the turbines.

3.3.1 Normal operation

Normal operation of the power plant with free-flowing discharge in the headrace tunnel is possible up to flow rates of approx. 10.7 m3 / sec. It turned out that appropriate ventilation of the relining pipe is to be provided if the water level rises above the lower edge of the upstream ceiling contraction wall.

3.3.2 Start of the suction operation

In order to achieve flow rates greater than 10.7 m^3 / s, the water level in the surge chamber had to be lowered accordingly (up to 0.7 m in nature).

Parallel to this, the air evacuation of the tunnel took place. It was found that negative pressures in the pipeline of a maximum of 1 m occurred. This resulted in the first minutes of the suction to a lowering of the water level in the upstream water at the nose by up to 90 cm, while the water level in the surge chamber remained largely constant.

3.3.3 Suction operation

Experiments carried out up to a maximum flow rate of 12.7 m^3 / sec with different water levels in the surge chamber showed that the evacuation of the air initiated suction operation can be stably maintained upright.

3.3.4 End of the suction operation

The turbine control allows the discharge to be reduced again (below 10.7 m3 / s) to stop the suction operation by supplying air in the water. The water level in the surge chamber increases accordingly. The water level at the beginning of the relined tunnel rises only slightly.

3.3.5 Emergency shutdown

During an emergency shutdown, the entire turbine water quantity has to be discharged suddenly via sluice gates in the surge chamber, without causing flooding. The experiments showed that this sudden increase in water level in the surge chamber can only be regulated safely with an additional outlet sluice gate.

4. Conclusion

The model tests carried out showed that the proposed hydraulic engineering solution works and allows the desired increase of the discharge up to 12.7 m^3 / s.