SCCER SoE

SWISS COMPETENCE CENTER for ENERGY RESEARCH
SUPPLY of ELECTRICITY

Swiss Competence Center on Supply for Electricity
Annual Conference 2015

In cooperation with the CTI

Energy
Swiss Competence Centers for Energy Research

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Commission for Technology and Innovation CTI

Characterisation of hydraulic behavior of surge tanks orifices

Nicolas J. ***ADAM***[(1)], *Giovanni* ***DE CESARE***[(1)] , *Anton J.* ***SCHLEISS***[(1)], *Pedro* ***MANSO***[(1,2)] *&* *Cécile* ***MUENCH-ALLIGNÉ***[(3)]

[(1)]Laboratory of Hydraulic Constructions (LCH), Ecole Polytechnique Fédérale de Lausanne (EPFL)
[(2)] Swiss Competence Center for Energy Research Supply of Electricity (SCCER-SoE)
[(3)] Institut Systèmes Industriels, HES-SO Valais-Wallis

1. Introduction

Hydroelectric plants have produced almost 60% of the total electricity production since 2000 in Switzerland. The Swiss storage power plants produced almost one third of the total production [SFOE, 2014]. Furthermore, this type of plants, and specifically high head power plants (Figure 1), are useful to follow cyclic peak demands (daily, weekly and seasonal) as they can provide large amount of electricity in a short lap of time. As new individual sources (solar and wind) have appeared, owners and producers may consider an increase of the peak generation of these plants.

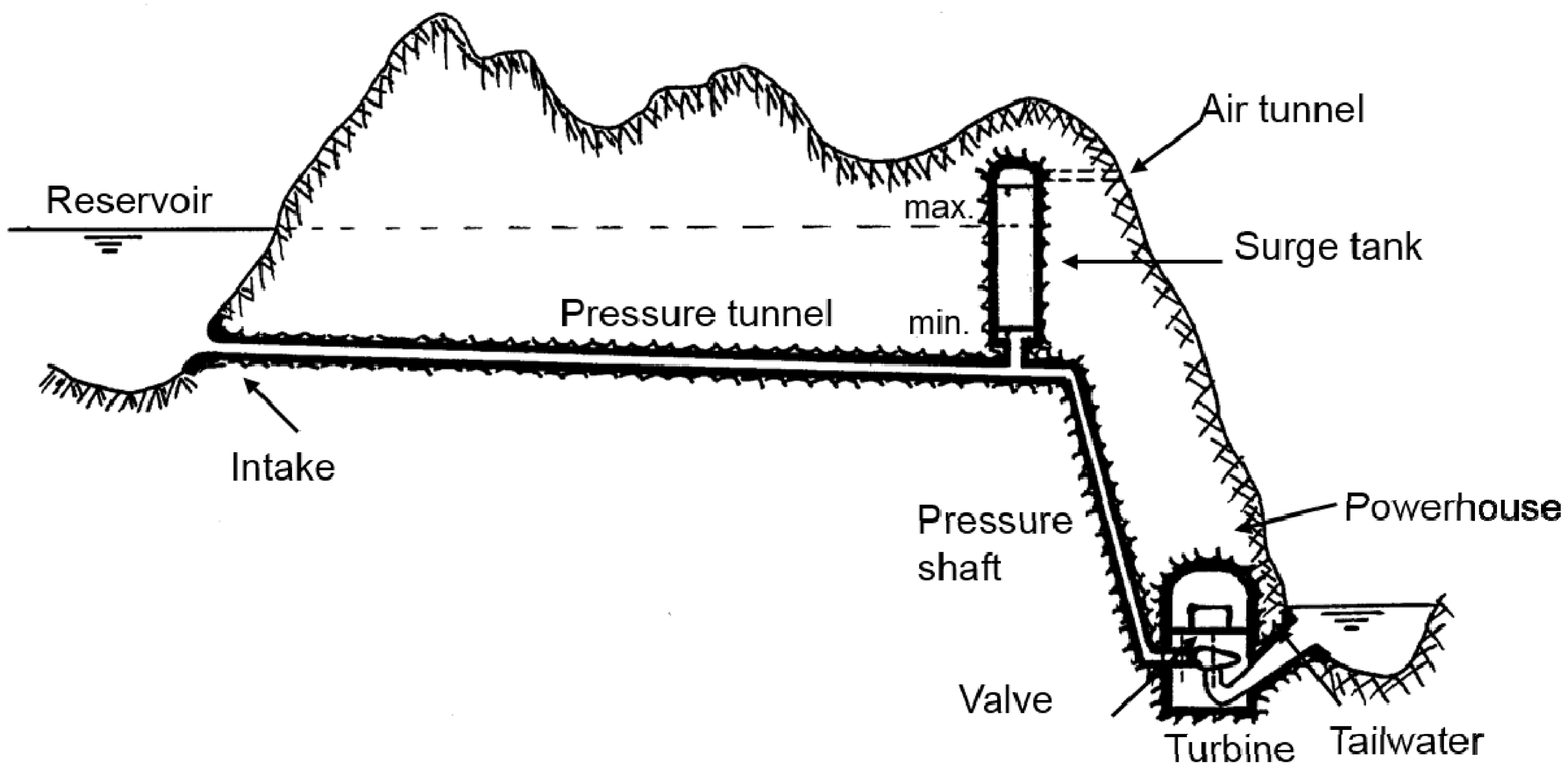

Figure 1 : Schematic view of a typical alpin high head power plant (H>200m) [Schleiss,2002]

Generally, an increasing of power capacity requires modifications to insure safe transient behaviors of the plant. Thus, the surge tank, which controls and damps discharge changes in the system, has to be modified. A simple and economical way to satisfy this safely behaviors is to place an orifice at the entrance of the surge tank. It ensures that pressures in the system remains acceptable when the time of closure or opening of downstream discharge controls is equivalent.

2. Objectives and methods

An orifice placement at the entrance of the surge tank needs usually iterative designs on physical scaled models in laboratory. The most challenging point is often the asymmetric head losses that orifices should produce. **This research aims to provides a catalogue of diaphragm head losses to decrease the number of iterations of physical studies by improving orifice draft designs**. For example, with target losses in both flow directions given by a first 1-D transient analysis, practical engineers should identify right orifice shape and geometry.

Both physical and numerical models are used to scan the largest possible head loss range in each directions. Two orifice shapes have been chosen to achieve this goal : the ASME (American Society of Mechanical Engineers) standard shape and an elliptical shape (Figure 2). Elliptical shape was found to be as close as possible to the relative ASME standard shape.
In this way, we are able to highlight the influence of the shape, orifice combinations on head loss coefficients and risk of cavitation to create the final catalogue.

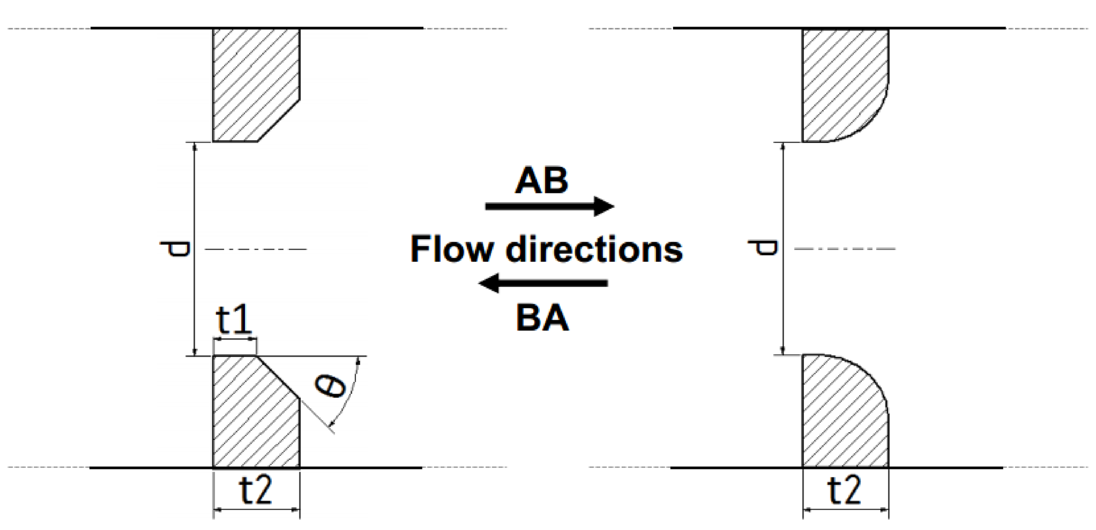

Figure 2 : Orifice cross-sections : ASME standard shape (left) and relative elliptical shape (right)

3. Experimental set-up

Both numerical and physical experiments have been undertaken at the LCH. The first tested set is the ASME-standard orifices. The experimental set-up is installed in the LCH laboratory in EPFL (Figure 3). The experimental set-up is equipped with 4-points pressure taps along the pipe to evaluate head losses and risk of cavitation and 1-point pressure taps along the pipe to evaluate natural frequency of the oscillating jet produced by the orifice (if it exists).

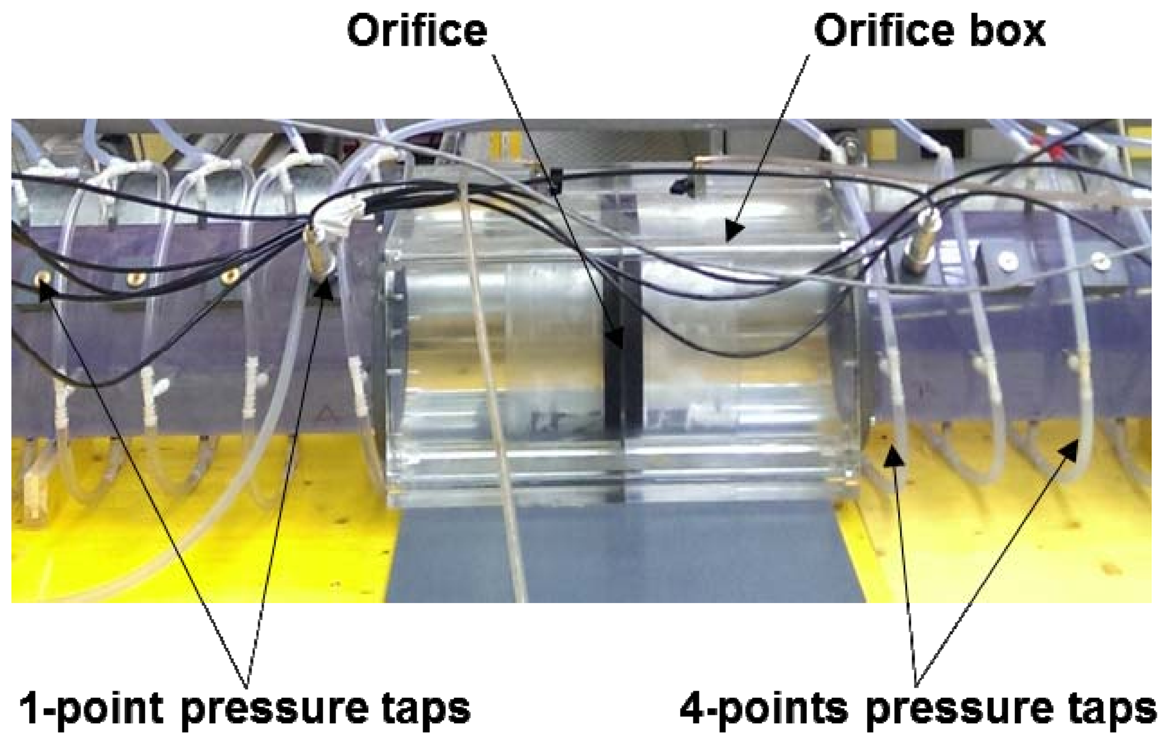

Figure 3 : View of the experimental set-up at LCH

4. Results

First numerical results investigated the influence of the θ-angle on the head loss coefficient (Figure 4, left). A comparison was carried out between the numerical and experimental results for the square-edged orifice.

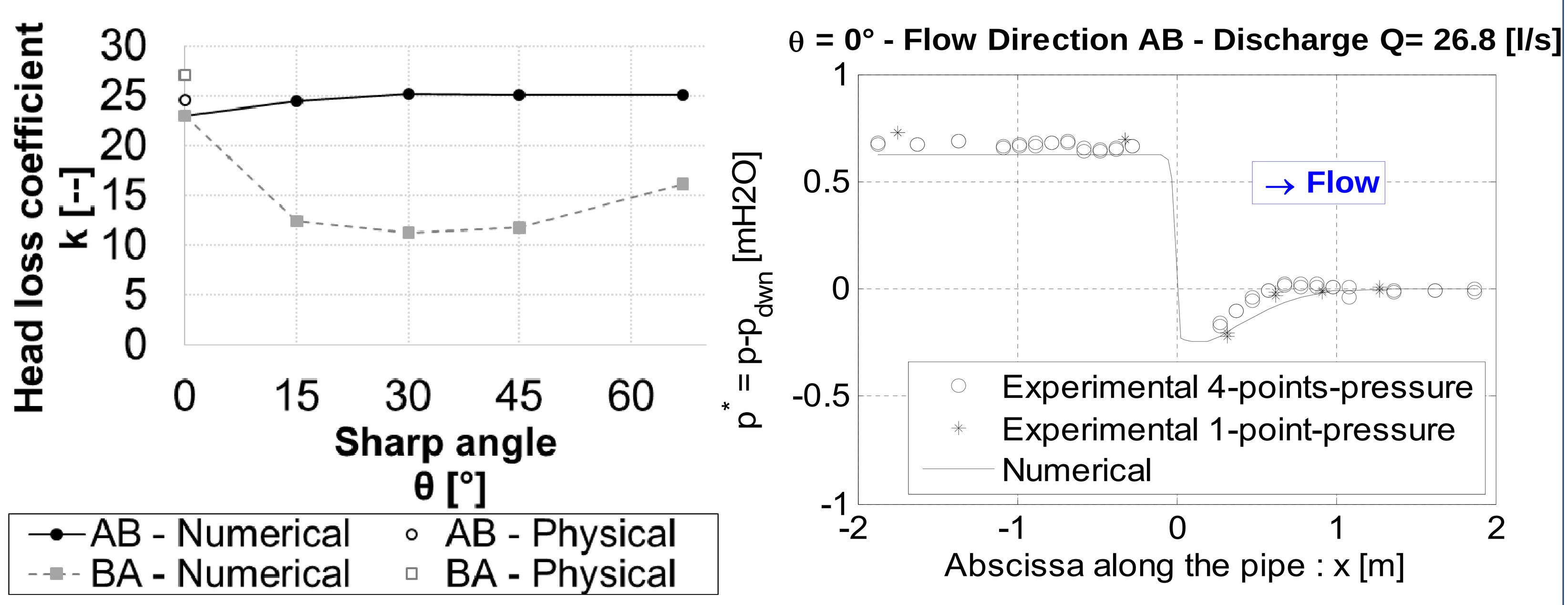

Figure 4 : Influence of the angle on the head loss coefficients (left) and a comparison between numerical and experimental results for square-edged orifice (right)

4. Conclusions and outlooks

This research focuses on the effect produced by an orifice placement and influencing parameters. Both numerical and experimental model are used to study these effects, i.e. head loss coefficient, risk of cavitation and oscillation frequencies.

Both numerical and physical experiments show that an angle placement in an orifice allows to have asymmetrical head losses with almost a 50-percent reduction with regard to flow direction. So far, there are still small differences between physical and numerical models which have to be studied.

Partners

The numerical models was built and performed in collaboration with the “Institut Systèmes Industriels (Hydroélectricité)” of the HES-SO Valais/Wallis.The first part of the research was financed by “The Ark: promoting innovation in Valais”.

Publications

[1] Adam, N.J., De Cesare G., (2015). **Diaphragm in pressure pipe: Steady state head loss evolution and transient phenomena.** *In 5th IAHR International Junior Researcher and Engineer Workshop on Hydraulic Structures.*

[2] De Cesare, G., Adam, N.J., Nicolet, C., Billeter, P., Angermayr, A., Valluy, B. (Abstract accepted). **Surge tank geometry modification for power increase.** *Hydro 2015 Conference.*