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Investigation of transient mixed flow at hydropower plant intake

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This study is performed in the framework of the **SmallFlex** project which aims to show that small-hydropower plants can provide winter peak energy and ancillary services, whilst remaining eco-compatible.

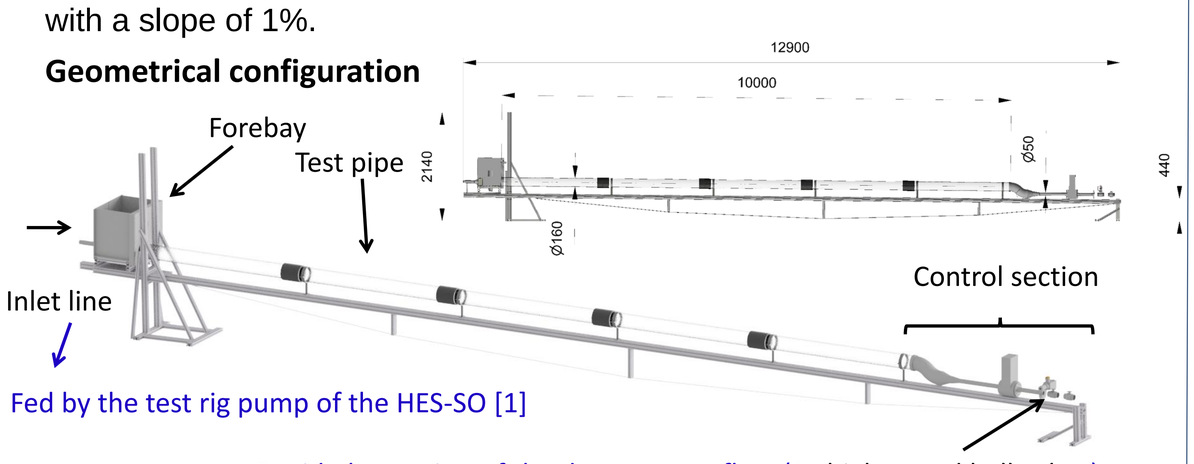
Objectives of this study

- Development, design and building of a reduced-scale test bench as well as its control to reproduce transient behaviour developing at hydropower plant intake and its penstock.
- Numerical modelling and simulations of those phenomena with Simsen.
- Analysis and comparison of numerical and experimental results for two test cases.

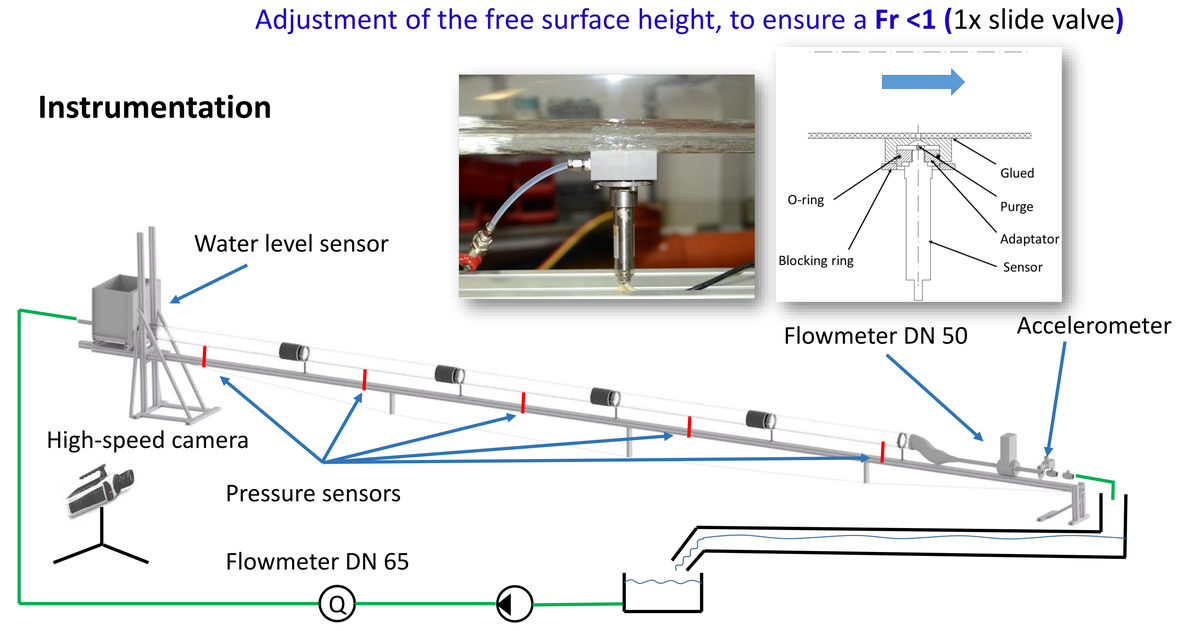
Laboratory reduced-scale test bench

The test bench is mainly manufactured with transparent parts to allow flow visualisation and contains a forebay, a test pipe and a control section. The whole test section is mounted on a inclinable support allowing slope setting. A return pipe, a free-surface tank and a pump completes the closed-loop hydraulic circuit. A high speed closing ball valve has been specially developed to obstruct the flow in less than 10 milliseconds. This obstruction speed generates a direct water hammer in case of a full filled pipe. The principal test case is a fast valve closure at the downstream of a mixed flow with a slope of 1%.

Geometrical configuration

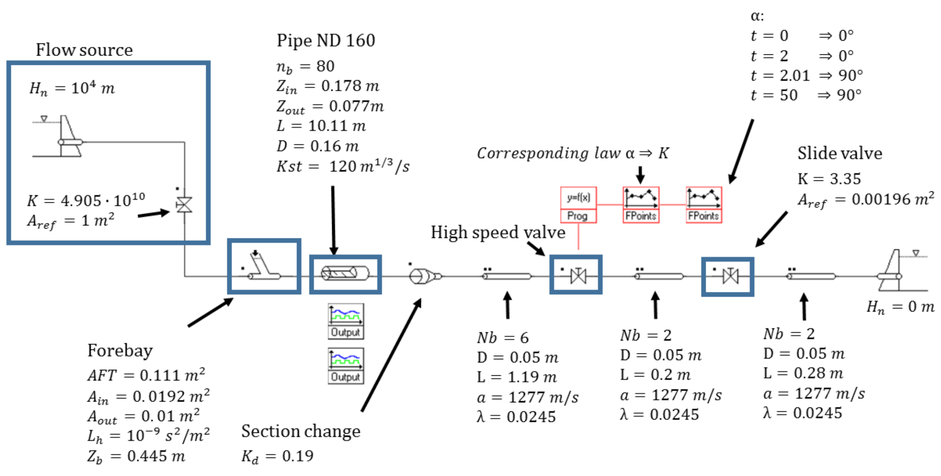


Instrumentation



Numerical approach

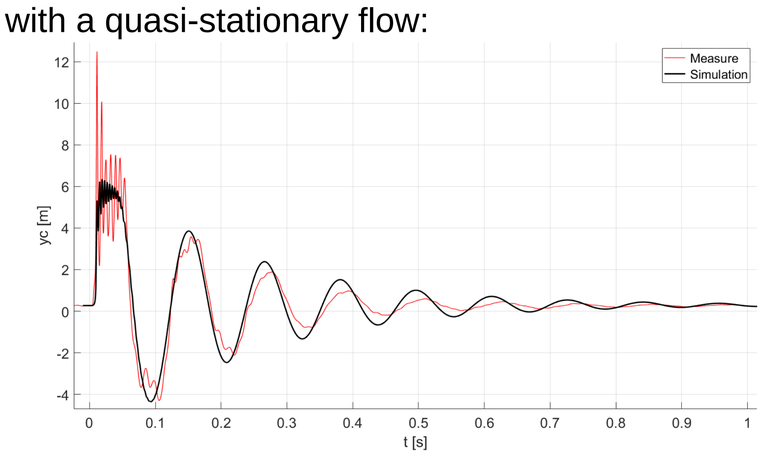
A compressible numerical approach was considered using a 1D software called Simsen [2]. This software allows to compute both transient electrical and hydraulic schemes. The Preissmann model [3], specially developed for the computation of transient compressible mixed flow, was used. The considered Simsen model is the following:



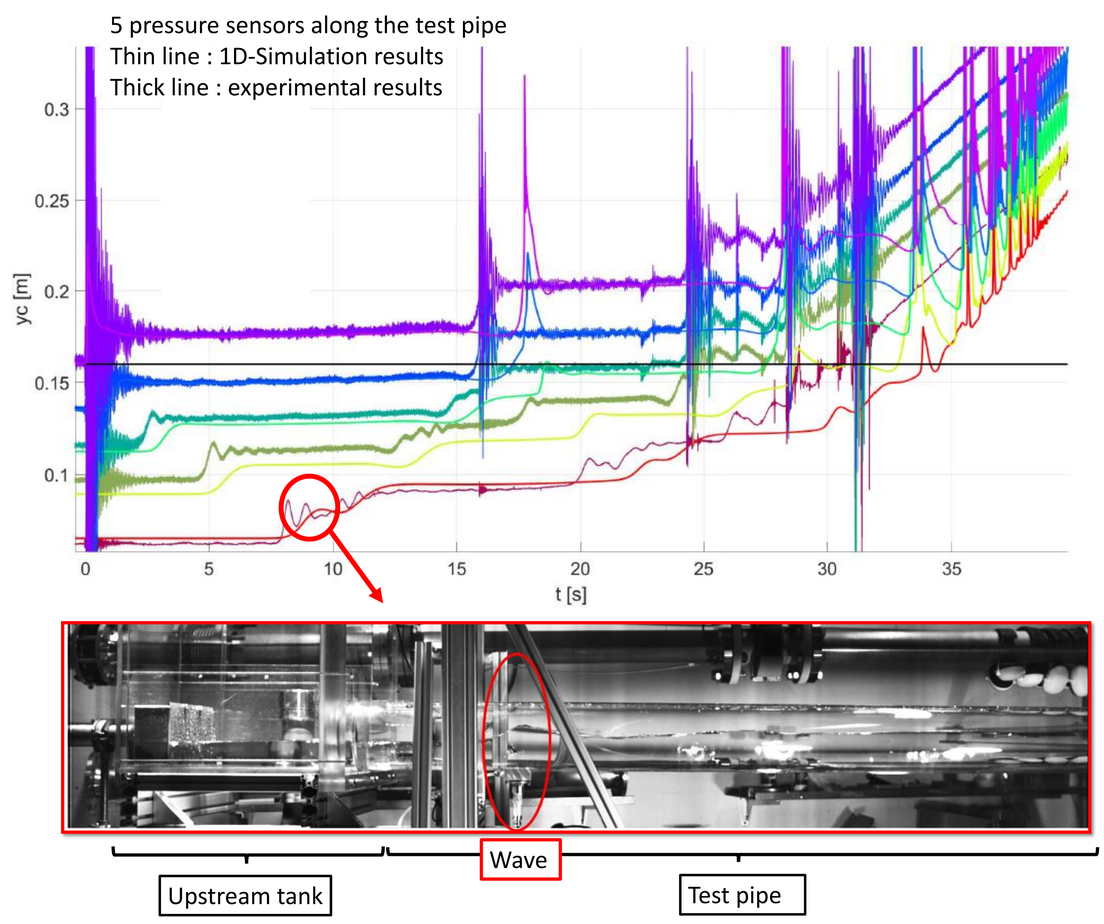
Results

Experimental and the numerical results have been compared in the case of a fast closure using the high speed valve. A good agreement is observed for both considered flow initial conditions, the fluid structure interactions being discarded.

1) Full pipe with a quasi-stationary flow:



2) Mixed flow in the test pipe, free surface mainly parallel to the pipe bottom, the end of the test pipe being completely filled. The flow was quasi-stationary and the Froude number was everywhere below 1.



Conclusions and perspectives

These investigations have shown that:

- The developed test bench allows to reproduce transient flow observed at the intake of hydropower plant.
- The transient behaviour of the flow, either monophasic or mixed, is globally well predict with Simsen 1D-Simulation with a correct calibration of some parameters.
- Ongoing work: development and implementation of a model able to simulate flows with a Froude number > 1 and its validation on this test bench.

Acknowledgements

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Power Vision Engineering

FMV

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[2] Nicolet, C., Greiveldinger, B., Hérou, J.-J., Kawkabani, B., Allenbach, P., Simond, J.-J., Avellan, F., High Order Modeling of Hydraulic Power Plant in Islanded Power Network, IEEE Transactions on Power Systems, Vol. 22, Number 4, November 2007, pp.: 1870-1881.

[3] Jean A Cunge and M Wegner. Intégration numérique des équations d'écoulement de barré de saint-venant par un schéma implicite de différences finies. La Houille Blanche, (1) :33–39, 1964.