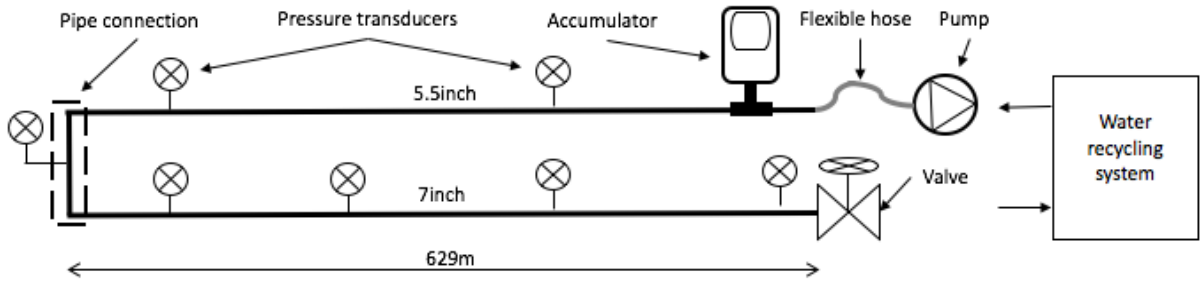
Initial testing on a pipe flow loop for the investigation of transient characteristics

Eirik M. Hansen, MSc Student, NTNU- The Norwegian University of Science and Technology

A good understanding of transient flows in pipes and ducts is essential to ensure safe operation of hydropower plants. Forced transients can be used actively to improve this understanding by means of e.g. frequency response measurements. FDB has initiated a project for large scale investigation of such transients at a test facility located outside of Stavanger, Norway. The test facility is operated by IRIS - The International Research Institute in Stavanger, and consists of two 700m long industrial scale pipes connected in series. During the 2017 spring semester, the experiments have been planned as a part of the master thesis of Eirik Myrvold Hansen, mechanical engineering student at NTNU. In the week May 8-12,2017, testing began at the facility.

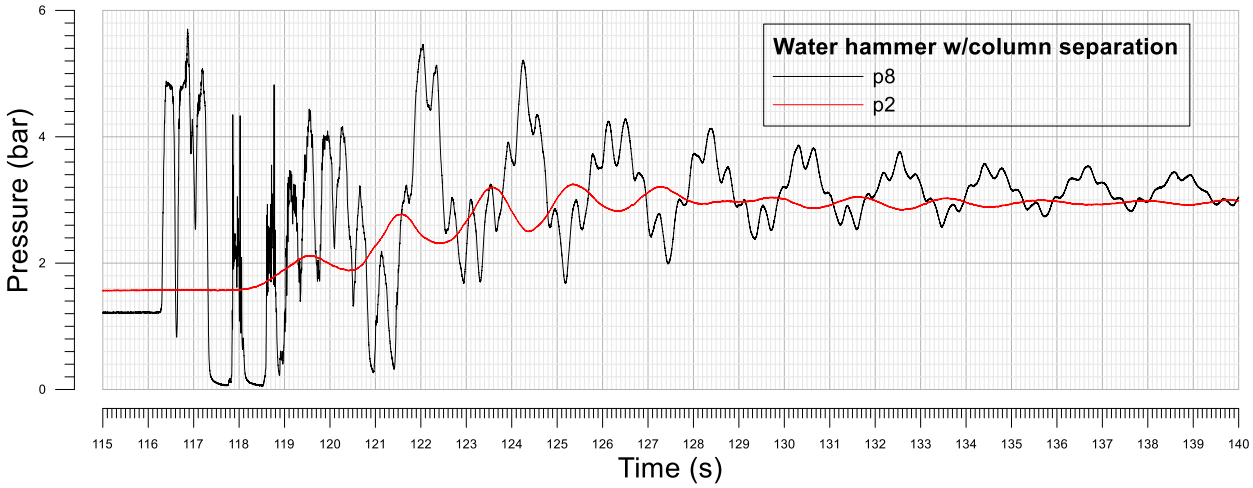
A photo illustrating the magnitude of the test facility. Good shoes for long walks were instrumental when installing pressure sensors along the pipes.

The first part of the week was used to install additional components necessary for achieving the required flow conditions in the flow loop. This involved pumps, valves, water recycling systems, an accumulator as well as equipment for measuring both flow and pressures throughout the system. A lot of effort was also put into developing good procedures for the preparation of the flow loop, involving procedures for clearing out entrapped air from the long pipes.



Schematic drawing showing the various components that makes up the flow loop

The first experiments involved the water hammer transient. This effect was achieved by closing the valve rapidly at the outlet end of the system. This caused elastic pressure waves to propagate back and forth through the system. From the first tests, it was evident that entrapped air was still present in the system. This was seen from how the pressure waves was reflected and dampened. After flushing the system once again, most of the air was cleared out and much better results were achieved.

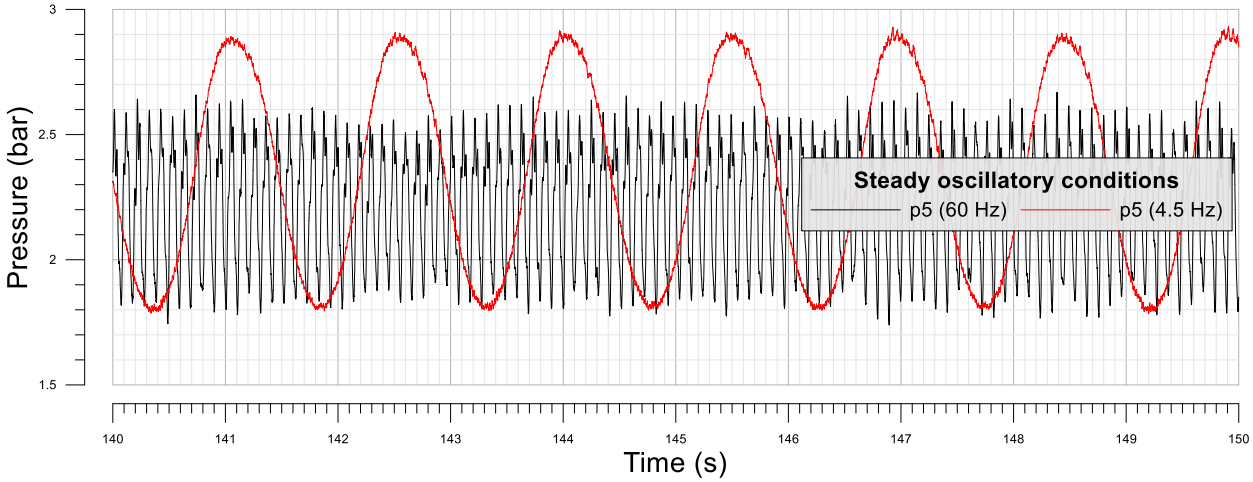


Time development of the measured pressure at two different locations separated more than 1000m apart and upstream of the closed valve. This result is from when air is still present in the system.

The second experiments involved an oscillatory flow. The oscillatory flow was achieved by installing a special type of valve at the outlet end of the pipe. This valve can excite the system at a wide range of both frequencies and amplitudes, providing a lot of interesting dynamics for further

investigation. This part of the experiments proved successful. All the components worked as expected, and the desired oscillatory behavior of the flow in the system was achieved.

Picture of the valve for generating oscillatory flow in the system during operation. The white disc is connected to a motor shaft, operating at various frequencies. The disc rotates across a small slit in the outlet cross section, effectively changing the outlet area and the pressure loss across the valve. One can expect to get a little wet when this runs at full speed.



Pressure response from sensor roughly 600m upstream the oscillating valve for two driving frequencies. Note: Frequency indicated refers to motor driving frequency, and does not include gear transmission ratio.

A lot of data was gathered during the week experiments, and a substantial amount of post processing remains to reveal the actual level of success of the experiments. The first publication related to this work will be the master thesis of Eirik Myrvold Hansen. Another publication by Svingen, Vilberg and Hansen is also planned in the coming months. The future for the flow loop includes more high fidelity testing by Svingen and Vilberg. The experience obtained during this week of testing will be used to further enhance the performance of the experiments.

All in all, it has been a hectic week involving a lot of learning by overcoming various challenges, both expected and unexpected. In conclusion, we are happy with the outcome of the experiments so far, and look forward to return to the test facility at IRIS.

Stavanger/Lier
May 2017

Participating in the project:

FDB Flow Design Bureau

IRIS International Research Institute of Stavanger

NTNU Norwegian University of Science and Technology

Project partially funded by the Research Council of Norway- The Industrial Ph.D Scheme and the Regional Research Fund- RFF Vest

Members of the project:

- MSc student NTNU and author of this document: Eirik M. Hansen (EMH)
- PhD candidate at NTNU/ FDB Employee: Ingrid K. Vilberg (IKV)
- Supervisors at NTNU: Prof. Bjørnar Svingen (for EMH) and Prof. Torbjørn K. Nielsen (for IKV)
- Supervisor at FDB: Dr.ing Morten Kjeldsen
- Contact at IRIS: Gunleik Sandsmark

The May-2017 testing also included a significant contribution by Olav Olsen (Torsion Tool Company), Steinar Lomeland (IRIS) and Carl Bergan (NTNU).

For inquiries about the project please contact:
Ingrid K. Vilberg, +47 93458754, ingrid.vilberg@fdb.no