INTERACTION OF A FILLING JET AND A VESSEL IN A LOCK

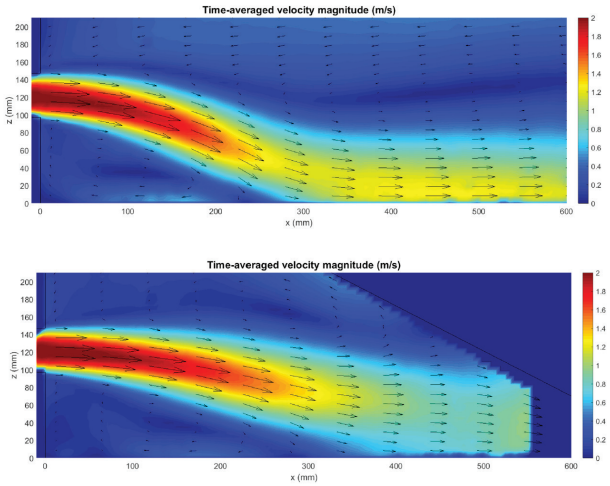
Accurate predictions of the forces exerted on a vessel during levelling are required during the design of shipping locks to ensure safe and swift operation. Those predictions are often made by distinguishing between several force mechanisms, of which the translatory wave, filling jet and density current are generally the most important. Predictions can be made using computational tools such as Lockfill, which was developed by Deltares.

This research project focused on the interaction of the filling jet with the ship using scale model measurements. The project was part of the knowledge programme for hydraulic structures, which is a collaboration involving Dutch knowledge institutes, Rijkswaterstaat and market parties for studying, among several other things, the levelling process in shipping locks.

Scale model measurements were performed at Deltares in a flume with a schematised lock and ship geometry. The geometry did not include any variation in the flume width in order to simplify the interpretation of the results and comply with the 2D assumptions of Lockfill. In addition to the forces on the ship, the flow pattern was also measured using highly detailed PIV (particle image velocimetry) flow measurements. All of the data obtained are available on data.4tu.nl.

The distance between the ship and the lock gates was varied during the tests. The results provided a detailed picture of the filling jet flowing into the lock. The PIV measurements, which were performed both with a ship located near the gate and with no ship present, showed that the filling jet is actually pulled upwards when a ship is located close to the gate. This counterintuitive observation can be explained by how the ship limits the dimensions of eddies occurring between the lock gate and ship's bow.

The jet's direction and spread are also affected by the lock geometry. The Coandă effect, or the jet's tendency to stick to the lock floor, was clear to see in the measurements. When accurate information is available about the spread of the jet, the force on the ship can be computed (using Lockfill, for example) on the basis of the jet's momentum flux.



Flow velocities measured with PIV, situation with a ship and without a ship

These measurements helped to understand how the ship affects the flow pattern and how, consequently, this flow exerts a force on the ship. The measured forces were compared with Lockfill model results and a good match was found, from which it could be concluded that this simple and computationally fast model still provides useful results. The insights generated by this study are valuable for the safe operation of existing locks, which need to handle higher traffic intensities and increasingly large vessels.

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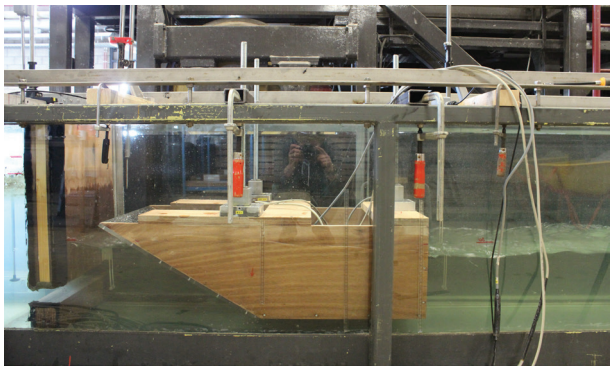
Further reading:

Van der Ven & Van Loon (2018), The Interaction of a Lock's Filling Jet and the Ship in the Lock Chamber, using Scale Model Measurements, International Symposium on Hydraulic Structures



Overview of measurement set-up

The filling discharge at the water surface for the Krammer recreational lock, Netherlands