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Depressurised Wave Basin Paves the Way for Joint Industry Projects

Marin's new Depressurised Wave Basin (DWB) has only just opened, but the first orders have already been booked. The basin offers new possibilities in research and is meant to contribute to joint industry projects between companies, government, knowledge institutes and the navy.

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Maxime Verhagen, the Dutch Minister of Economic Affairs, Agriculture and Innovation, performed the DWB's official inauguration on 19 March. President of Marin Bas Buchner welcomed the Minister and explained why the new basin is unique and how it can be used for research and testing. Minister Verhagen complimented Marin with its new facility and its contribution to the economic and social goals the government is aiming at. With the new basin, companies, government, knowledge institutes and the navy can cooperate in joint industry projects, the first of which are ready to begin.
The opening ceremony was performed inside the basin, the pressure during operation can be lowered to 2500 Pa. Tradition calls that every representative of colleague facilities brings a bottle of water

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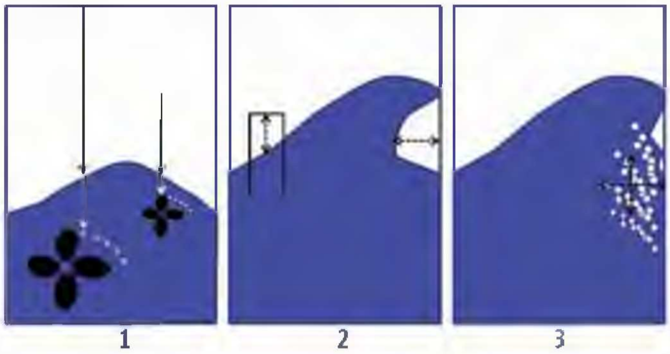
from their own facility that will be mixed with the water of the new basin. In this way, cooperation and merging of knowledge to reach synergy is symbolised. A small basin shaped like the "golden triangle" of knowledge institutes, government and business was used for this ceremony and every representative of the present parties poured the water from their own "facility" into the small basin. All kinds of fluids were brought, like dredging sludge by a dredging company and blue, orange and "fire water" by the students of TU Delft. Then Minister Verhagen opened the valve so the water could flow into the new basin and at the same time a spectacular laser show started. The wave generators were started and the waves travelled for 1.5 minutes across the basin to break on the other side on the new beaches.



The new DWB allows for research on for example cavitation (left), and wave forces and flooding (middle and right)

The Basin

The basin's essential features are the wave generators on two sides (and beaches on the opposite) and the air pressure control in the entire basin, which can be decreased to as low as 2.5 per cent of the atmospheric pressure. These capabilities allow many new physical aspects to be studied because of the proper scaling.
The physical essence of testing with a geometrically similar, but smaller model is the control of the physical properties that are responsible for reaching meaningful similarity on the relevant physical aspects. In maritime context, we then talk about accelerations (including gravity), speeds, aircontent and pressures. These variables are the dominant physical features governing forces, motions, cavitation and noise in the (two phase) flow. Below some concrete research areas are shortly discussed.

Research Areas

- *Cavitation & noise:* Cavitation is the "boiling" of the water in areas of very low pressure (lower than vapour pressure). Typical locations are behind the heavily loaded propeller or rudder. To study cavitation behaviour before, an entire self-propelled ship model up to 12 m in length had to be tested for its cavitation and noise behaviour in still water. Now this can also be done in waves or even while manoeuvring.
  The main reasons for avoiding cavitation is the collapsing of the vapour bubbles, which causes either damage to the propeller or rudder and/or creates a lot of noise and pressure pulses. The latter ultimately leading to vibration.
  Illustration 1 showing the propellers in the figure above explains why the pressure needs to be scaled down. The lower forces exerted on the water by the smaller propeller (causing the pressure drop behind the blade) matches the lower water column above the model propeller, but also requires the air column (80 km) to come down to the model properties. Lowering the ambient pressure in the basin is the way to solve this.
- *Wave forces and flooding:* Forces exerted by waves or any flow on offshore structures and ships are essentially a flow either containing air or meeting air while hitting/filling the structure. The correct scaling of these air cavities such as air chambers and air cushions (illustrations 2 and 3) enables the measurement of loads exerted on offshore structures, piles and on the insides of tanks. The forces on wave energy converters can also be measured, either as part of the aimed energy recovery process or as an assessment of the extreme loads. The modelling of the flooding process as part of an installation or of a damaged ship assessment is enabled through the correct scaling of the ambient pressure for the trapped air.
- *Slamming:* As with the waves hitting offshore structures, waves can hit a ship and cause damage or at least slow a ship down. With wave generators installed at the side and end of the wave basin, ships can now be tested in a wide range of operational conditions to assess these possibly damaging forces. With the ambient air pressure being scaled, the behaviour of trapped air for slamming and wave impacts is correctly modelled. The entrapped air in particular, significantly reduces the extreme forces. Not lowering the ambient pressure on model scale would make the air pockets or bubbles much too stiff, hence causing either too high forces and/or exerting the model at the wrong frequencies.
- *Resistance & propulsion:* The facility can still be used as a multipurpose model basin for hydrodynamic research related to the resistance and propulsion of ships, current forces and dynamics relevant for offshore structures. The available combination of waves and basin length allows an efficient use of the basin.

Technical Data

The basin measures 240 x 18 x 8 m. The preparation harbour is 26 m long and 4.2 m wide. Up to 100 measurement channels can be acquired up to 100 kHz. A hydrophone array of two is fitted to the DWB, either fixed or moving along with the carriage, with a 30 Hz to 100 kHz measurement range and sensitivity of -186 dB (at 1 m distance). The basin can be depressurised to a minimum of 2500 Pa (25 mBar).

Creating Waves

Dry-back multi-flap wave generators are positioned along the full width of the short side and along 120 m of the long adjacent side of

the basin. They can be used to realise long and short crested waves from various directions. The force-feedback control compensates possible reflections from the model and the beaches, which are facing the wave generators.
The long side wave generators can generate waves with wave heights of 0.4 m at a 3 s wave period, the short side generators can create waves with a wave height of 0.75 m at a 4 s wave period. Combining these waves and translating them to full scale creates a wave no one wants to meet at sea.

Observation Systems

Remote-controlled high-speed cameras and high-powered LEDs can be positioned anywhere within the model or in submerged housings fixed to the carriage, offering great flexibility in illumination and an excellent view of the cavitation behaviour at a minimum frame rate of 4000 frames per second.

Carriages

The basin is equipped with: a towing carriage for hydrodynamic tests on ship models and a second silent carriage measuring radiated noise from ship models and propellers.
Various sub frames can be mounted on the main carriage, which allow preparation in the harbour outside the DWB. The model enters through a pressure lock and is then connected to the main carriage for testing.
This sub-carriage can be fitted with four dedicated modules:

- A resistance and propulsion dynamometer test frame for towed models.
- An observation module that carries all equipment required for cavitation observation and hull-pressure fluctuation tests.
- A seakeeping test frame for free sailing models.
- A test frame that is fitted with a six degree-of-freedom forced oscillation Hexapod.

The carriage can reach a speed of 6 m/s and is fitted with an optical 3D position measuring system used for measuring model motions.
The basin is fitted with a second silent carriage for noise measurements. The background noise of the silent towing carriage allows radiated noise measurements of ship propellers that need to comply with the ICES CR209 standard. By using the two hydrophones fitted in the DWB, it is possible to measure flow noise, the noise of breaking bow waves, or noise from the propeller, both in the near and far field. The silent carriage is fitted with a mooring ring so that fixed or moored test subjects can be rotated and exposed to any wave direction.