MARIN assists The Ocean Cleanup by testing its pioneering barrier

The Dutch foundation The Ocean Cleanup is developing technologies to extract plastic debris from the oceans and currently, the organisation is designing a barrier that will concentrate and extract the plastic from the Great Pacific Garbage Patch. Joost Sterenborg, j.sterenborg@marin.nl

Barriers are not new in the maritime industry as booms have been used to confine oil spills for many years. However, in contrast to the barriers used to confine oil, the plastic concentration barriers are deployed for extended periods of time and can be much longer. The Ocean Cleanup is considering developing barriers of up to 100 km in length. This heavily impacts the requirements on the structural and material properties of the barrier and how they are going to be moored also has to be considered.

100 km barrier The design of the barrier, which consists of a floating element and a screen, is still in the conceptual phase. MARIN assisted in the design process by conducting model tests in its Offshore Basin for a 360 m barrier segment at a scale of about 1:18. The two main goals of the tests were to provide loads and displacements for numerical model calibrations and to examine the 3D fluid-structure interactions and the barrier performance. Extreme conditions were focused on to explore the limits of the system and its ability to capture plastic.

Figure 1: event of overtopping

Figure 2: event of bridging

To achieve these targets MARIN monitored the loads in the mooring and the displacements of the barrier. The performance of the underwater screen, which is crucial to confine the plastic material, was assessed using underwater video. Events such as overtopping and bridging influence the plastic capturing efficiency of the barrier. Therefore, MARIN focused on identifying the likelihood of these events of which examples are provided in Figure 1 and 2.

During the model tests, three different mooring concepts were examined, whereby the barrier geometry was unchanged. See Figure 3 for underwater view. For the first concept the barrier is moored every 60 m to a submerged line connected to underwater buoys. In the Basin the underwater buoys were not modelled but the submerged line was modelled using a tension line. In reality, the barrier will be longer than the 360 m model. To mimic tensions in the barrier that occur due to hydrodynamic forces on the barrier segment that was not modelled, pre-tensioned mooring lines were attached to both ends of the floater of the barrier.
For the second and third concept, mooring lines were attached solely to the ends of the bottom of the screen or the floater of the barrier respectively.

For each mooring configuration static load and decay tests were executed. As well as this, tests with current only, regular waves with current and irregular waves with current were conducted. For the second mooring concept different pre-tensions in the mooring lines were assessed to model different lengths of barrier.

Three mooring concepts These 3D model tests gave good initial insight into the loads, barrier motions and the operational limits of the barrier. The tests also demonstrated that three-dimensional testing is crucial, as the global barrier behaviour was quite different compared to the two-dimensional tests that The Ocean Cleanup had previously conducted. Bridging occurred in only a few test cases and the first concept proved to be the least susceptible to overtopping.

Based on the measured motions and forces, The Ocean Cleanup worked on the calibration of a numerical model. Using this model more extensive research will be conducted by The Ocean Cleanup, incorporating the full length of the barrier.

In June, The Ocean Cleanup assessed the plastic capturing efficiency of the barrier in more detail by conducting new model tests at MARIN. These model tests provide data for the validation of computational fluid dynamics (CFD) calculations.

MARIN will also be involved in full-scale measurements on a prototype barrier installed in the North Sea this year. The main objective here is to monitor the effects of real sea conditions on the barrier's motions, with a focus on waves and currents.

Figure 3: Underwater view of mooring concept 1, 2 and 3 (source: The Ocean Cleanup)