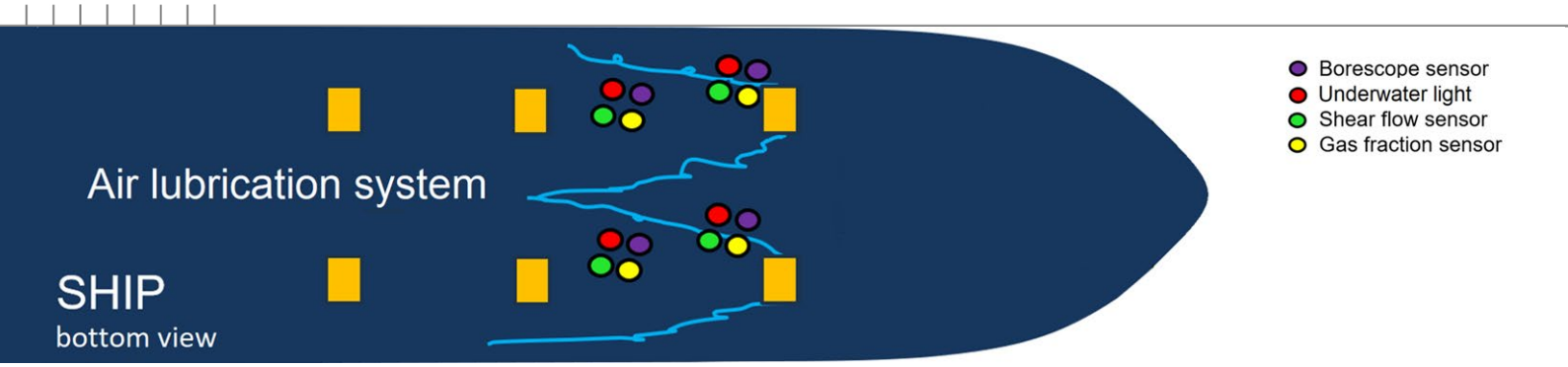


Air lubrication measurements at full-scale

Developing the tools needed to quantify air lubrication effectiveness

Air lubrication systems are being installed on a growing number of vessels. Two main types are in use today: air cavity systems and bubble injection systems. Operational experience shows that activating these systems often increases speed, while propulsive power typically decreases, though it may also increase or remain unchanged. However, long-term measurements under real operating conditions often provide inconclusive results on net energy savings. Questions also remain about whether these systems are operated optimally and how performance can be improved. MARIN addresses this challenge by developing novel sensors to quantify the local flow properties of the air lubrication layer.

Services for shipowners:

- Quantification of the power performance of the ship.
- Visualisation of the local properties of the air lubrication layer.
- Quantification of the gas fraction at certain points of the bubbly air lubrication layer.
- Relative quantification of the effect of air lubrication on the local shear stress of the flow.

New sensors for measuring air lubrication systems

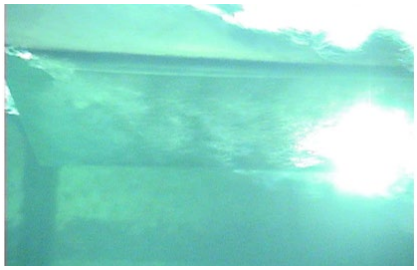
MARIN is currently working on developing the following sensors:

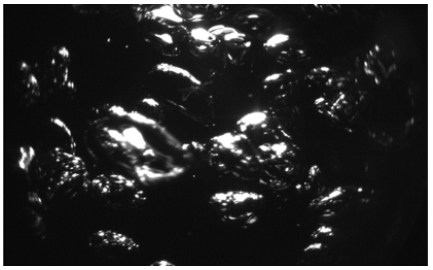
- Visualisation equipment
- Gas fraction sensor
- Wall shear stress sensor

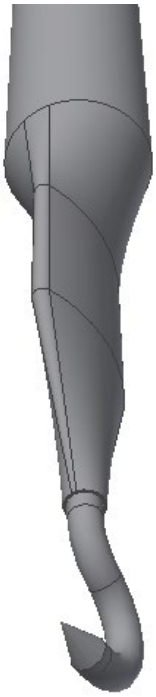
Each sensor provides a different perspective on the air lubrication system, adding complementary information that helps to build a more complete performance picture. The details of the individual sensors are outlined below.

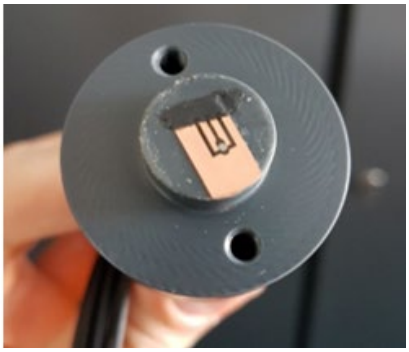
Visualisation equipment

For visualising the air layer, a camera mounted on a borescope is envisaged, combined with lighting at each measurement location. The illumination is positioned on the same side as the camera. The borescope will have a standard viewing angle to minimise distortion, for example 55°. The borescope–camera setup should produce sharp images from a few centimetres away up to a distance of 1–2 metres.









Related services:

- Speed/power trials.
- Observation of flow phenomena at the propeller, rudder or appendages.
- Stern wave measurements.

For more information contact MARIN:
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The light is introduced into the flow using LEDs mounted on rods, recently developed at MARIN. For this application, new rods may need to be designed, with LEDs positioned at 90° to the rod axis.

Gas fraction sensor

It is proposed to measure the local gas fraction using a newly designed needle-based sensor. The design philosophy focuses on maximising robustness and ease of installation. The needles of the new sensor are envisaged to be 2–3 mm thick, providing sufficient strength to withstand flow forces and potential impact from small debris at sea. Each needle has an exposed tip capable of detecting the presence of air or water.
The needles are mounted on a rod that can be lowered from inside the vessel, allowing installation and retrieval without the need for divers. This also enables sensors to be replaced during trials if rods become damaged or cease functioning. The rod has a diameter of 16 mm at the top, tapering towards the bottom near the needles.

A key requirement for the rod design is that it must be strong enough to resist flow forces while also accommodating internal wiring for the needles. In addition, the rod shape (circular, elliptical, or wing profile) influences the severity of vortex-induced vibrations. Both aspects must be considered in the design, which should be tested at full speed (22 kn) before a full-scale sensor is produced.

Wall shear stress sensor

It is proposed to measure the local wall shear stress using hot-film sensors. These are thin pieces of celluloid that contain conductors; on one side, they are glued to a substrate and on the other side they are exposed to the flow. At the sensor position, the conductors are very thin which makes them heat up when current is passed through the sensor. Heating up causes the resistance of the sensor to change. When water flows over the sensor, the sensor cools down, again causing the resistance to change. The change in resistance is related to the local flow shear stress.

For full-scale application, the sensors should be fixed to rods that fit in the standard borescope opening in the hull (16 mm diameter). In this way, the sensors can be installed and deinstalled without the need for drydocking. Also, the rods would need to be designed such that it is easy to make the sensors flush with the hull from inside the ship.

Possibilities for cooperation

MARIN is seeking partners to further develop these sensors and bring the technology onboard. If you are a shipowner, ship designer, shipbuilder, or a designer or manufacturer of air lubrication systems, please contact us to explore opportunities for applying these measurement systems on your vessels.