Bio-inspired surfaces to reduce vibration induced by the turbulent boundary layer

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Bio-inspired coatings and materials are increasingly used to improve the efficiency of marine vehicles. In the last decades, several analyses focused on the reduction of frictional drag by means of surfaces that mimic the fish skin as well as the plant leaves have been carried out. In particular, a number of investigations have been devoted to analyze the mechanisms of interaction between the turbulent boundary layer (TBL) and water-repellent coatings, with the specific aim to reduce frictional drag [1]. On the basis of laboratory experiments, performed both in laminar and in turbulent flow regimes, it has been demonstrated that drag reduction up to 50% is possible if super-hydrophobic surfaces (SHSs) are considered [2]. Though, the physical phenomena that originates frictional drag are also responsible for vibration of elastic structures and noise radiation, this last being one of the major source of disturbances for the ship on-board sensors or for towed sensor's arrays. Little has been done to analyze the effects of SHSs on vibration and noise induced by TBL, in [3] a first attempt to perform experiments at open sea to compare the noise spectra detected by coated and uncoated sensor line arrays is presented, showing results unlikely to be interpreted.
On the other hand, it is well recognized that SH condition is unstable and that SHS performances are limited for underwater application since an increase in hydrostatic pressure associated with a change in depth, can lead to fast air layer degradation. A different approach to obtain a highly water repellent surface consists in replacing air trapped in the surface features with a liquid that is immiscible in water, to form a Slippery Liquid-Infused Porous Surface (SLIPS) that have already provided encouraging results in terms of drag resistance reduction and long-term stability [4]. To study the effect of SLIPs, an experimental setup has been designed to measure, in a high speed channel (see Figure 1), friction drag and vibration induced by TBL underneath flat plates at moderate Reynolds number values ($Re \approx 10^6$). The attention has been focused on assessing material performances with respect to flow velocity, surface roughness and viscosity of the interface, obtained testing different oils. Preliminary results shown a reduction of the acceleration response of the coated plates for all tested velocities, in specific frequency ranges. Some insights into the physical mechanisms affecting wall pressure fluctuation spectra and induced structural response are discussed.

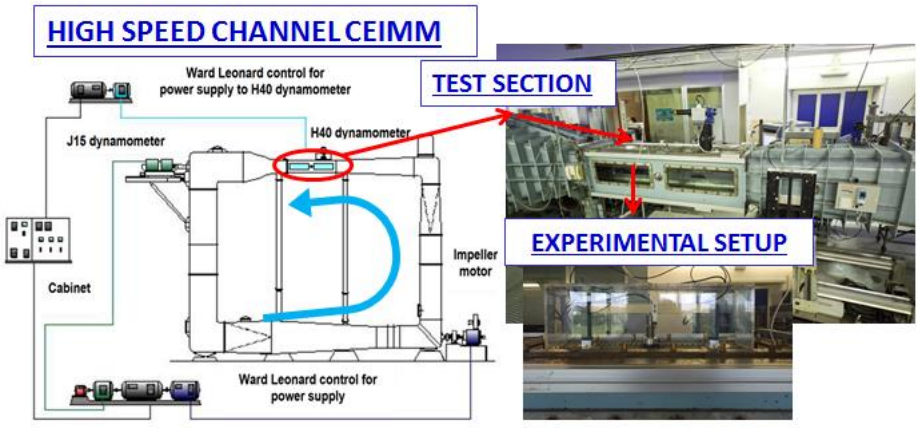

Figure 1. Experimental facility and setup for drag and vibration tests on SHSs

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