Open water characteristics of three model scale flexible propellers

Luca Savio *† and Kourosh Koushan*†

* Department of Ship and Ocean Structures
SINTEF Ocean
Trondheim, Norway
e-mail: Luca.Savio@sintef.no , web page: https://www.sintef.no/ocean/

† Department of Marine Technology
Norges teknisk-naturvitenskapelige universitet (NTNU)
Trondheim, Norway
e-mail: kontakt@marin.ntnu.no - Web page: https://www.ntnu.edu/imt

ABSTRACT

The hydroelastic behavior of propellers has been a recurring topic in ship propulsion; seen at times as a possible cause for failures of propulsive systems and some other times as an opportunity for improving the performances of propellers as a noise and vibration sources, it often suffered from a lack of experimental material to validate design and analysis codes. There are, as a matter of facts, very stringent limitations on what can be done in experiments on propeller models in hydrodynamic facilities. These limitations arise both from the scaling laws the experiments abide to and from the difficulties in producing flexible, with controlled mechanical properties, propeller blades. However, the progresses in computer simulations of fluids and structures allow for another strategy to be sought. In fact, it is possible to use the numerical simulations as a link between the model scale experiments, where the test conditions can be accurately controlled, and the full scale products, which is where hydroelasticity ultimately matters. The strategy, that is often used in hydrodynamics, is to validate the codes in model scale, in this way ensuring that can be used to simulate full scale phenomena.

In this paper we present the results from a series of tests carried out on three homogeneous and isotropic flexible propeller blade sets. The three propellers are variations of the same geometry, where the original blade skew distribution was altered. The blades were produced both in aluminum and in a epoxy-like resin, through the technique of resin casting. The aluminum blades served to make the form for the resin blades, and as a reference as rigid blades since their elasticity can be neglected in model scale. The tests were carried out in SINTEF Ocean's large towing tank in open water condition, i.e the inflow to the propeller was uniformly distributed. The tests were performed at different propeller rotational speeds and at different pitch settings. In order to establish a reference condition for the flexible propellers, all the tested conditions were also run with the rigid blades; in this way, it was possible to quantify the significance of the different Reynolds number at which the blades were tested. It is worth pointing out that the terms rigid and flexible are used here to refer to the blades made of aluminum and resin respectively; in fact, even-though also the aluminum blades are strictly speaking flexible, their stiffness in model scale makes any deformations under the effect of hydrodynamic loads too small to be observable; on the contrary, the resin blades clearly show deformation when loaded that can be measured by the laboratory equipment. Care was taken not to excite any resonance in the blades. Furthermore, since the inflow was homogeneous, the response of the blades was static. Becuase of the lack of any dynamics, the tests presented here fall under the category of static hydroelasticity. The blade geometries and the results from the tests can be obtained upon request to serve as validation material for numerical simulation codes.