

Experimental study of the slamming wave impact on deformable composite structures

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I. INTRODUCTION

Until a few decades ago, the use of fibre-reinforced composites in marine environment was limited to sport vessels (speedboats, jetskis, sailing yachts) and a number of military applications. The composite structure was designed very stiff and quasi-rigid, in order to resist the slamming wave impact. Wave impact or slamming is characterized by high local peak pressures (up till 10 bar and more) with a very short duration (typically milliseconds) [1]. Two types of slamming are distinguished: (i) bottom slamming, where the structure rises out of the water and then falls back into the water, and (ii) breaking wave slamming, where a wave breaks just at the moment that it hits the structure from the side.

In recent years however, composite materials are applied more and more in ship construction (catamarans, high speed craft,...) and offshore structures, because of their corrosion resistance, limited maintenance, long life time (up to 20 years) and sometimes even cheaper cost. Moreover, demands of light weight engineering and reduction of material consumption lead to less massive structures that can no longer be considered as rigid. This is basically a good thing, because if the structure allows for any deformation, the local peak pressures induced by slamming waves, will be lower than in the case of a rigid structure [2]. However, the effect of slamming wave impact on deformable composite structures and the evolution of the possible damage has hardly been studied, and there is a need for fundamental research to answer the following questions:

(i) what is the effect of this very local peak pressure, that moves very fast in time along the surface of the structure, on the local deformation of the composite material ?

(ii) which damage is caused by the repeated wave impact in the composite structure, and can this gradual deterioration of the composite material be modelled in terms of maximum stresses/strains during one single slamming wave impact ?

II. PLANNED RESEARCH

A. Experimental set-up for lab-scale slamming tests

During a recent master thesis in UGent-MMS, a lab-scale experimental set-up for slamming was built [3]. Figure 1 shows the concept and Figure 2 the actual set-up. The component is attached to a ladder that is mounted as a cantilever beam above a water basin. At the edge of the basin, the ladder is mounted on a shaft that is connected to a controlling motor.

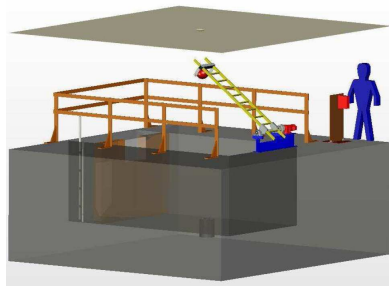


Figure 1 Illustration of the slamming test facility



Figure 2 Actual slamming set-up

Both bottom and breaking wave slamming can be simulated by mounting the component on the ladder in a different position. This set-up is nearly finished as concerns mechanical assembly and electrical connections, but the necessary control and instrumentation has not been developed yet. Further, the filament winding machine of the research group has been adapted to wind axisymmetric composite structures on a lab-scale.

B. Experimental test program for deformable composite structures

A first series of experiments on (quasi-)rigid bodies must allow to validate the test set-up. Indeed, there is sufficient published data available, both experimental and numerical studies, for slamming on rigid bodies with a simple geometry. For these tests, components will be made as rigid as possible, e.g. using cast polyurethane resins, plasters or full foam shapes with a rigid skin. By means of embedded pressure sensors and strain gauges, it will be verified if the peak pressures correspond with the published ones and the deformations of the component are indeed negligible.

In a second step, deformable composite components are manufactured, at first instance also axisymmetric. Due to the flexibility of the filament winding set-up, the stiffness, curvature and wall thickness of the composite structure can be varied very easily. Also the winding-in of foam for creating

sandwich structures, is possible. Slamming of flat plates onto the water surface will be considered as well, because (i) the peak pressures are in this case the highest, and (ii) it has already been demonstrated that the effect of the air layer between plate and water surface cannot be neglected in case of flat plate entry (the so-called ‘cushioning effect’) and the modelling of this phenomenon is quite complex [2].

III. OBJECTIVES

The objectives of this research are twofold:

(i) carrying out extensively instrumented slamming tests on deformable composite structures, including the monitoring of the resulting instantaneous deformations and the damage and stiffness degradation of the composite material,

(ii) the parametric study of the effect of the geometrical and mechanical properties of the composite structure (thickness, curvature, stiffness) on the local peak pressures and the slamming phenomenon.

The fluid-structure interaction, will not be part of this PhD, as is the focus of another cooperative research project.

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