UNIVERSITI TEKNOLOGI MARA

AN ANALYSIS OF FLUID-STRUCTURE INTERACTION FOR HULL LAMINATED WITH FIBRE REINFORCED POLYMER

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ABSTRACT

The focal point of a ship or boat is called a hull which involves the bottom parts, all sides, and the deck. Planing hull laminates are the plies which are stacked at the various orientations. Several factors affecting the hull laminate process include matrix cracking, interface debonding, delamination, or fibre breakage. The crucial factors in the selection of resin thermoset and laminates for the FRP include, durability, strength, lifetime, and the cost involved. The objectives of this study incorporate (i) to determine the optimum tensile strength for various layer stack sequences and orientations of woven roving, +45°, -45°, and 90°, (ii) to determine the initial fatigue damage leading to crack initiation by using the Fatigue Test, (iii) to verify the strength and the initial fatigue damage leading to crack initiation using Finite Element Analysis (FEA) in ANSYS Software, and (iv) to evaluate the wave impact of the wave slamming on the hull (Fluid-Structure Interaction) by using ANSYS Aqwa software. Hand lay-up was deployed to prepare the hull laminates which were stacked in sequence with an orientation where each layer is a different type of fibre mat and the orientation is at woven roving angle of +45°, -45°, and 90°. The four groups of the symmetric and balanced design of the specimen laminate are comprised of +45°, -45°, and 90°. A Tensile Test specimen size of 250mm x 25mm x 8mm was prepared according to ASTM 3039D and the American Bureau of Shipping (ABS) rules. The strength of various laminates of FRP with 9-layer of a tissue mat, chopped strand mat 450 and woven roving 600 with unsaturated polyester were also measured. The ultimate tensile strength was measured using the Universal Testing Machine (UTM) for the Experimental Approach, and the ANSYS software for the FEA approach. The initial fatigue damage is the measurement for the crack initiation using dynamic machine for the experimental approach and the ANSYS software for the FEA approach. In this research, the crack initiation has been measured by a matrix cracking measuring tool, Dino-Lite. The ANSYS software is deployed to simulate the strength and fatigue damage. In addition, the software evaluates the wave impact of slamming on FSI which could assist to resolve the wave slamming circumstance. The ultimate tensile strength resulted from the experimental approach and FEA approach is specimen AI+45°, 130 MPa and 150 MPa respectively. The initial fatigue damage which led to the crack initiation has resulted in the matrix cracking on the surface of the tissue mat, the first layer of the laminate. The minimum matrix cracking length is 0.2722mm while 6.1333mm is the maximum. The results of the specimen from this research have been used for boat model simulation. Implementation of simulation on the real model to address the real impacts found that the maximum pressure of 1793.75MPa occurred at the stern of the hull on the first laminate layer. The research findings found an increase in the ultimate tensile strength, reduction of the matrix crack and the wave impact of the slamming on the FSI. The results are significant in terms of the high strength, durability, and the potential to fabricate new boats. The fact that FRP is both isotropic and oriented makes it stronger, more durable, and easier to be deployed for new buildings and performed maintenance and repairs. Furthermore, composites made of virgin FRP materials emit fewer greenhouse gases and utilise less energy than steel.

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