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Use of composite materials in shipbuilding. Utility and necessity

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Abstract. The paper analyses the characteristics of composite materials and makes a comparison with those commonly used in shipbuilding and on board equipment. The necessity to use composite materials at the expense of classical ones is presented, also taking into account the requirements of the ship's crew and shipowner. Analysis is carried out and practical proposals are made for the use of these materials on the ship's body and on mechanical and electrical equipment.

1. Introduction

Marine vessels have always been an important research topic and the use of composite materials in this area has become a necessity thanks to the new international requirements. In the maritime industry the reduce of the production and maintenance costs, increased safety and environmental protection are indispensable. Composite materials based on polymer fibers were used in the construction of military vessels because of their nonmagnetic properties and as a countermeasure against mines. The low weight of sandwich and rigidized composite materials led to the construction of high-speed vessels [1].

Composite materials, due to anisotropy, are used: to reduce construction, exploitation and maintenance costs because it diminishes corrosion; to reduce the mass of the vessel because they are lighter by reducing the carbon footprint; to reduce the environmental footprint of ships; for easier manufacture and the development of complex hull forms; for the realization of electromechanical equipment in the composition of the naval power system.

Joined composite materials are an alternative because, unlike welding that requires boarding the ship on the dock and represents a fire hazard, they are free from defects, they adapt to any geometry and can be installed at any location.

The mechanical properties of the composite materials were determined following cathodic dissociation tests. Cathodic dissociation is applied in practice and this is considered in the design standards [3, 4].

The composite system is more impact and corrosion resistant, and the matrix is stronger than a coating. As a disadvantage, the composite materials are prone to fractures over ferrous coatings that are more malleable.

In LPG (liquified petroleum gas) vessels, gas tanks are made of composite materials that are lighter and have a superior corrosion resistance and replace steel containers.

2. Sandwich structures

For composite sandwich marine construction vessels, different researches have been carried out concerning their characteristics [1] – Figure1 – strength reduction curve for sandwich face sheets when subjected to in plane tensile loading following the introduction of face sheet impact damage represented by holes of varying sizes.

The use of new sandwich-metallic structures, including extruded aluminum, laser-welded steel and steel-elastomer systems, contributes to the realization of new generations of marine vessels with a new structure [5]. The advantages of using steel and aluminum sandwich systems are: improving safety and reliability, reducing weight and space, and increasing ship body and equipment efficiency. A sandwich concept that has managed to overcome the prudent nature of the shipping industry is the Sandwich Plate System (SPS). This is a composite material technology in which two steel plates are glued to a dense elastomeric core [6].

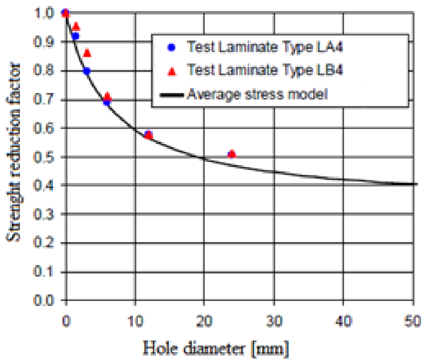

Figure 1. Strength reduction curve for sandwich sheets when subjected to a traction test

The study analyzes a wide range of panel lengths and widths and focuses, in particular, on combining transverse pressure loads with shear and compression forces in the plane. Elastomeric materials for use in the sandwich plate (SPS) system, glass fiber and carbon fiber, epoxy systems and resins are used in the naval field.

3. Mechanical vibration analysis in sandwich structures

Mechanical vibrations are a dynamic phenomena that occur as a result of a potential and kinetic energy exchange resulting in oscillation movement around a position considered equilibrium. To explain the phenomena that occur during mechanical stresses on the sandwich structures, the stress-deformations diagram is analyzed. The material is solicited at plates level and at ship level. It was approached the problem of analytical structural analysis for three-dimensional structures using 15 equations - Cauchy, Hooke and equilibrium, to fully describe the state of stresses and deformations [7]. The structural analysis is based on the knowledge of deformations in the ship's plates and the stresses that occur with the determination of their vibration frequencies.

The plates deformations decrease twice with the stiffening of the ship's body. Figure 2 represents the state of deformation for the transversely and longitudinally stiffened body and Figure 3 represents the state of deformation [8,9].

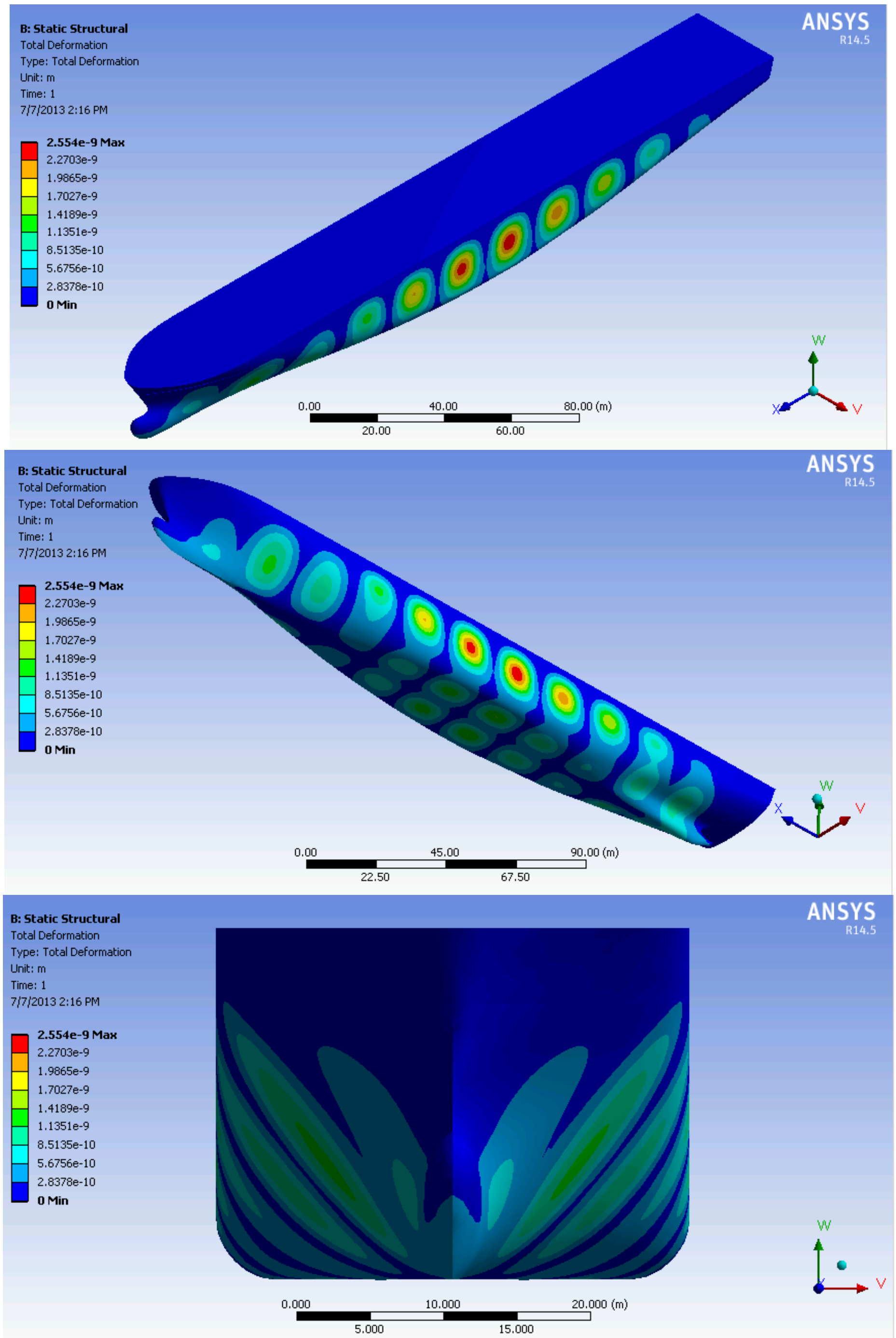

Figure 2. Deformation state for the transversely and longitudinally stiffened body when subjected to stresses

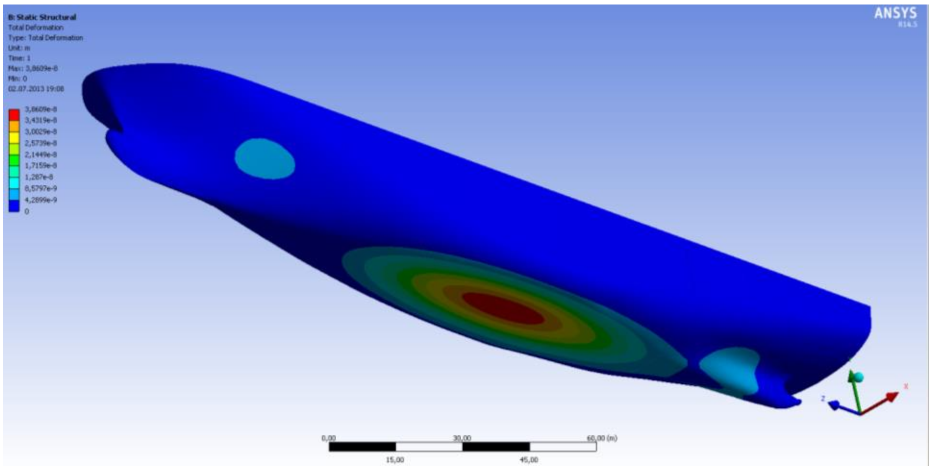

Figure 3. Deformation state for the unstiffened body subjected to stresses

Conclusions

A composite material can be described as a combination of two or more distinct materials that at microscopic level retain their own properties and structure, but at macroscopic level the resulting material appears to be homogeneous. The entire assembly has different characteristics and properties in relation to each component material. It is important to study the structure and properties of composite materials.

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