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Fibre Reinforced Plastic Material with Aluminum Filling Used for Ship Superstructure

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ABSTRACT

FRP materials predominantly prolonged their usage in industries present at offshore in latest years. Even though low cost, simple maintenance, light weight and superior corrosion resistance were acknowledged as chief benefits of utilizing FRP materials, the fibre reinforced material design are naturally not as much implicit as those for metallic counterpart. FRP's degradation over long term requires characteristic strength design techniques, criteria of acceptance and procedures of testing. Use of plastic fibre will increase the fire hazard in the ship at the same time using the carbon fibre will increase the rate of the material. Requirements of regulatory safety too put in restrictions with regard to design on electric conductivity and endurance of fire that may not be predominant for metal. In this research we are discussing the critical design and fabrication of the fibre reinforced material with mixing of carbon fibre and plastic fibre with aluminum nano powder used as filling. We are covering three major considerations including, the strength and suggested methods of design for FRP used for ship super structure, the techniques to achieve requirements for fire test, and the choice of testing requirements interpretation.

KEY WORDS: FRP, Ship Super Structure, Refin Forced Material.

1. INTRODUCTION

Over the last thirty years, marine grade aluminium composite have seen increasing use in both commercial vessels and surface warships, particularly in decks and superstructures. However, it's use in recent warship construction has diminished rapidly because of problems of thermal softening under fire and endemic cracking in superstructures bonded to steel hulls have more the negated the notion of topside weight saving. Even though low cost, easy maintenance, light weight and superior corrosion resistance were acknowledged as chief benefits of utilizing FRP materials fire hazard is a major constraint in offshore industry. Numerous standards with different levels of details looking into certification and design of FRP piping which has been installed on platforms at offshore exist. Fibre reinforced plastic with plastic fibres will have a low fire resistant property at the same time it is having very good strength and stability. Due to low fire resistant property we cannot use this material in the shipping industry. But fibre reinforced plastic with carbon fibre will have very good fire resistant and fire retardant property and it can be used as an alternate material for the steel in the ship super structure but due to its more cost when compare with the normal steel fabrication this kind of material is not taken into consideration. In this paper we are going to discuss about the fibre reinforced plastic material with mixture of both carbon and plastic fibre with various compositions and aluminum nano powder will be used as a filling. Table 1 shows the differences between steel material and composite construction.

Table.1.Differences between steel and composites construction

Property	Steel Construction	Composite Construction
Weight	High	Allows Significant Reduction in Structural Weight
Corrosion	Rusts in Marine Environment Resulting in High Maintenance Cost	Very Durable in Marine Environment
Combustibility	Non-Combustible, will not Contribute to Fire or Generate Toxic Fumes	Combustible, Surface must be Protected in Fire Hazard Areas
Thermal Conductivity	High, must be Insulated to Prevent Fire Propagation and to Control Infrared signature	Low, Inherent Insulation more than Sufficient
Electrical Conductivity	High, Inherently Provides Electromagnetic Shielding	Maintenance Low, Must Embed Conductive layer If Electromagnetic Shielding is Needed

2. MATERIALS

2.1. Glass fibre material: Glass fibres originate with a choice of grouping of Al_2O_3, MgO, SiO_2, CaO, or B_2O_3, in form of powder. Later on these mixtures were heated via direct melting to temperatures approximately 1300 degrees Celsius, then leading to extrusion from dies, the glass fibre filaments of diameter in the range from 9 to 17µm, whereas filaments extruded by this method are later wound into threads that are large and onto bobbins it gets spun to transport and process further.

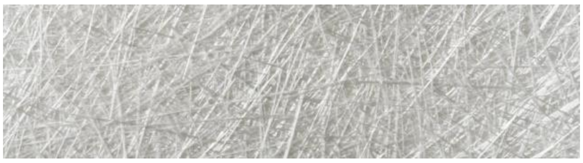

Fig.1.Glass fibre

Glass fibre is in Fig. 1 is a most familiar way of reinforcing plastic and hence cherish a wealth of production processes, few of those are pertinent to aramid and carbon fibres too owing to their collective qualities of fibres. Filaments get spun into threads of diameter of large range is known to be Roving process, which are later typically utilized in woven reinforcing glass fabrics, mats and in spray applications.

Fibre fabrics known to be web-form fabric material of reinforcing which possess both warped and weft directions. Fibre mats were glass fibres of web-form non-woven mats. Mats have been manufactured in cut dimensions using fibres that are chopped, or in mats that are continuous using fibres which are continuous. Fibre glass that are chopped finds its application in processes where glass threads lengths are cut between 3 and 26mm, later on utilizes in plastics highly proposed for processes of moulding. Short strands of Glass fibre measures 0.2 to 0.3mm and these glass fibres strands are highly utilized in reinforcing thermoplastics most usually in injection moulding.

2.2. Aluminium powder: Aluminium powder is powdered aluminum. This was originally produced by mechanical means using a stamp mill to create flakes. The resulting powder might then be processed further in a ball mill to flatten it into flakes for use as a coating or pigment. Aluminium is a comparatively durable, malleable, ductile, soft and lightweight metal with exterior looking in a choice of silvery to dull gray, relying on the roughness of surface and is nonmagnetic and difficult to ignite. A fresh film of aluminum exhibits as a well-known reflector just about 92% of light that is visible and an amazing reflector of medium and far infra-red radiation. Pure aluminum has 7 to 11M Pa of yield strength, while alloys of aluminum possess yield strengths in the range of 200MPa to 600MPa. Aluminium possess about the density which is one third and steel stiffness. Machining, casting, drawing and extrusion are easy. Atoms of Aluminium are lined up in a face centered cubic structure and it has stacking-fault energy of just about 200mJ/m^2. Aluminium exhibits a property of being a good conductor of thermal and electrical, possessing 59% the copper's conductivity, both thermal and electrical, since possessing copper's density of only 30%. Aluminium is potent to be a superconductor, with 1.2Kelvin as superconducting critical temperature and just about 100gauss of a critical magnetic field.

2.3. Carbon fibre: Carbons fibres is in Fig. 2 are produced when poly acryl nitrile fibres or Pitch resin or Rayon are carbonized at temperatures of high range. Graphitizing or stretching are the further processes that the strength or elasticity of fibres could be improved correspondingly. Carbon fibres are produced in diameters analogous to glass fibres with diameters in a range of 9 to 17µm and those fibres wound into threads that are larger which are used in transportation and further processes of production.

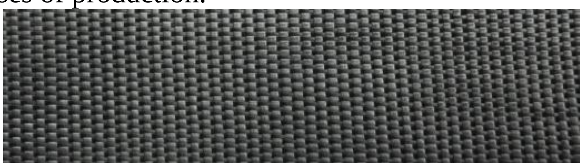

Fig.2.Carbon Fibre

Additional processes of production incorporate weaving or braiding into cloths, mats and carbon fabrics analogous to the ones explained for glass which find its application in definite reinforcements. Every carbon filament thread is a package of thousands of carbon filaments. A single filament is a tube that is thin of 5 to 8micrometers diameter and possess almost completely of carbon. Carbon fiber's Atomic structure of is similar to graphite, possessing carbon atoms sheet organized in a hexagonal pattern that is regular, the difference is that interlocking of sheets occur. Crystalline material i.e Graphite is where the stacked sheets are parallel to each other in regular fashion. Intermolecular forces among the sheets are comparatively weak, offering soft and brittle characteristics to graphite. Relying on the precursor for making the fiber, carbon fiber might be turbo stratic or graphitic, or hold a structure that is hybrid with both graphitic and turbo stratic parts present. The carbon atoms sheets of turbo stratic carbon fiber are randomly crumpled or folded jointly. Carbon fibers are turbostratic that are achieved from Polyacrylonitrile (PAN), whereas carbon fibers of mesophase pitch are graphitic beyong heat treatment at temperatures over 2200°C.

2.4. Epoxy resin: Epoxy from epoxy resins is the cured end product, and also the colloquial name for the epoxide functional group. Epoxy resins, also called as poly epoxides are a group of pre polymers that are reactive and polymers containing groups of epoxide. Epoxy resins may be react (cross-linked) either among themselves via catalytic homo-polymerisation, or with a choice of co-reactants together with poly functional acids (and acid anhydrides), alcohols, phenols, amines and thiols whereas these co-reactants are known to be hardeners or curatives, and the cross-linking reaction is typically referred to be curing. Poly epoxides reaction among themselves or with poly functional hardeners end up in formation of a polymer that is thermosetting, repeatedly with mechanical properties which are strong together with high temperature and resistance towards chemical. Epoxy finds its application like high tension electrical insulators, metal coatings, structural adhesives, use in electronics / electrical components and fiber reinforced plastic materials.

2.5. Wet layup: Wet layup forming associates fibre reinforcement and the matrix since they find their places over forming tool. Layers of Reinforcing Fibre have been placed in a mould that is open and then with a resin that is wet and saturated on pouring it above the fabric and working it into the fabric. Mould is later left aside for allowing the resin to cure, mostly at room temperature, even if heat is at times utilized for proper curing. Occasionally a vacuum bag is utilized for compressing a layup that is wet. Glass fibres are most frequently utilized in this process.

2.6. Location of Ship Where We can use FRP Materials: Machinery Spaces Walkways, Ladders, Platforms Cargo Tanks, All personnel Walkways, Coverings of Sea chest, Small Sundeck Awnings, Bilge Flooring of Lifeboat, Electrical Control Flooring, Guards for Pipe, Removable Guards, Personnel Barriers, Ship Staging and Work Platforms.

2.7. Tests Made on Fibre Reinforced Plastic: The long-term permissible axial stress is estimated by an association of tests and calculations. Given that components of FRP piping are prepared using materials which are non-isotropic, the permissible axial stress is usually, Axial Strength, Bending Strength, Buckling Strength, Compatibility of Material, Conditions of Environment, Resistance towards Impact, Analysis of Stress, Endurance of Fire, Fire Test, Electrical Conductivity.

2.8. Electrical Conductivity: Electrostatic discharge of FRP that is Uncontrollable might ignite a spark and bring in explosions in an environment that is rich in vapour. Electrical conductivity requirement towards the offshore FRP conventionally adopts IMO Resolution A.753. FRP materials, which are non-conductive, are hence not permitted in areas that are hazardous onboard ships and platforms which are offshore despite of the conveyed fluid. In offshore applications, Practical experience as discussed in, conversely, discloses that the prescriptive guidance offered by the IMO regulation looks to be highly restrictive. ABS Guide offers a functionality dependant approach with preference of potential electrostatic accumulation and mechanisms of discharge. Alternatively, the demand of electrical conductivity level may be calculated via a functioning capability dependant technique.

2.9. Fire Endurance: Fire resistance and high-temperature composite materials, such as carbon fiber reinforced composites and metal matrix composites, are widely used in aerospace or defenses industries. However, these types of materials can hardly provide a cost efficient solution for the FRP used in offshore oil and gas industry. The most commonly used FRP material in offshore platforms is Glass Fibre Reinforced Plastics (GFRP), which typically have a relatively low fire endurance limit. The ABS Guide provides detailed testing requirements for increasingly stringent Level 1, 2, and 3 fire endurance tests. The fire performance of a pipe system is rated according to a fire classification code representing the prescribed level of service function, fire type and performance.

2.10. Structural Fire Integrity: The structural fire integrity matrix bringing in the structural fire integrity uniqueness which the grating of FRP must possess, depend upon service and location. On satisfaction of a specific application which is higher than one block in the matrix, the greatest fire integrity level shall be necessary. Procedures of testing are necessary for qualifying the gratings of FRP gratings to one of three levels.

(a) Level 1: FRP gratings satisfying the L_1 criteria for performance are proposed to be acceptable for usage in escape routes or access for fighting fire, rescue or emergency operation later on exposing to an important hydrocarbon or fire incident which is cellulosic. Additionally for the services and functions described for levels L_2 and L_3, they are acceptable.

(b) Level 2: FRP gratings conforming the L_2 criteria of performance are proposed to be acceptable for usage in open deck areas where people in groups are probable to come together like temporary safe refuge or lifeboat embarkation areas. Additionally for the services and functions described for level L3, they are also acceptable.

(c) Level 3: FRP gratings conforming the L_3 criteria of performance are proposed to be acceptable for usage in egress routes and any areas requiring access for firefighting, rescue or emergency operations while exposing to or shortly later to exposure to a transitory hydrocarbon or cellulosic fire.

2.11. Fire Retardant: All FRP gratings must be fire retardant; which can be established by testing to ASTM E 84, Standard Test Method for the Burning Characteristics over Surface of Building Materials with a rate of flame spread not beyond 25.

2.12. Flame Spread: All FRP gratings, except those built-in on open decks and within tanks, void spaces, pipe tunnels and ducts, cofferdams must possess characteristics of low flame spread as calculated by one of the following procedures of testing to ASTM E84 with a rate of flame spread not beyond 20.

2.13. Smoke Generation: FRP gratings within service and control spaces, accommodation must possess low smoke characteristics as calculated by one of the following procedures of testing to ASTM E84 with a rate of smoke development not beyond 10.

2.14. Lightweight Structure: Reasons for using lightweight materials and arrangements of structure in ships
- They allow a better payload for a provided vessel's size or weight
- They allow greater speeds to be achieved
- They reduce consumption of fuel and emissions towards environment for a provided payload and distance travelled

2.15. Recent Development: Subsequent to a description of structures that are lightweight and their current usage in shipbuilding, emphasis is put on naval applications of composites, and in particular on features associated with cost benefit evaluation and survivability. Following part reports on the usage of adhesive bonding over superstructures of high-speed craft and passenger ships. It focuses on choice of material, designing and analyzing, manufacturing and application. In past 20 to 30 years numerous developments in lightweight construction comes in. In this period the aluminum alloys usage and composites of fibre reinforced polymers in the ship building industry has raised up steadily. Civilian applications incorporate vessels of high speed together with predominant parts of the superstructures of huge ships for passengers. Military applications incorporate fast patrol craft, larger naval ships superstructures and mine hunters. Freshly, revolutionary solutions of being lightweight involve features like adhesive bonding and innovative kind of construction of sandwich have been the further research focus and enhancement. Few of these enhancements are based on pioneering usage of steel together with the more common materials that are lightweight. Application areas were extended for including added components of conventional ships, namely ramps and moveable car decks. Additional advantages of FRP sandwich include very good flexural stiffness and strength for low weight, a high margin against catastrophic failure or penetration because of the two skins, high buoyancy, good built-in thermal insulation, and the ability to build both large and small structures without costly moulds. Sandwich structures generally allow the lowest level of stiffeners to be dispensed with, giving smooth surfaces and a compact structure. Furthermore, the skin laminates are used optimally so that relatively expensive skin materials can be used without undue cost penalty. Disadvantages of FRP include high initial cost and in many case a need for adequate fire protection, low elastic modulus.

2.16. Future research challenges: For FRP composites the main research and development challenges today concern material characterization and the need to ensure that the properties assumed in design are compatible with those achieved by the real production process. The situation is made especially difficult by the constant introduction of new or modified component materials and new processes. There is particular vagueness about the effect of production defects and damage, especially on the compression strength of laminates with carbon or other high strength fibres. There is considerable scope for development of faster and more reliable processes for nondestructive inspection of composites, particularly sandwich structures, and for methods of ensuring greater consistency in production. Other topics requiring R&D concern improved fire performance, including lightweight fire protection systems, development of reliability based design codes that take proper account of the multiplicity of failure mechanisms that are possible with composites, proper characterization of nonlinear structural behavior including buckling, and recycling. For aluminum alloys, the main challenges concern joining methods that are less costly and detrimental to mechanical properties than conventional welding processes. Indeed, for all lightweight materials, joining of both similar and dissimilar materials by novel processes such as adhesive bonding provides a series of challenges that are well worth facing because the potential returns are very great indeed. Lightweight structures tend to be more flexible than conventional steel structures. This means that buckling, vibrations and hydro elastic effects such as springing and whipping may have to be addressed to a greater extent than with conventional structures. Provision of adequate impact, collision and grounding resistance also provides some research challenges, particularly for aluminum hull structures.

2.17. Proposed methodology using finite element analysis (FEA): The aim of the structural analysis is to demonstrate by direct analysis that the permissible stresses set by the classification society are not exceeded in the given load cases. As no direct calculation method was available for the structural design of this structure, finite element modeling was used. The FEA software used for the calculation was NISA V9.0. The type of analysis was static and linear. The element types were 4 or 8 noded shell elements. One ramp and two platforms were modeled successively. Due to their quasi symmetrical layout, only one half or one quarter of the structure was modeled. The steel material properties used were as given in TABLE 3. In accordance with the DNV Rules for Ships (ref. 41) the allowable stresses were calculated to be sn = 160 N/mm² for the direct stresses and tn= 90 N/mm² for the shear stresses. The Z-profiles were not modeled but were assumed to behave as I-profiles. The sandwich panels were modeled with a mesh size of 120×75 mm (length × width mm). The longitudinal girders used for supporting the panels were modeled. The top flange (40×6 mm) was omitted in the model. The transverse girders were modeled as positioned, i.e. exactly below the sandwich stiffeners. However, the square tube used for the connection was not modeled. The webs of the girders were in most cases 290×6 mm but with tapers in some cases. In the vicinity of cleats and cut outs the web thickness was sometimes increased. The thickness of the bottom flange of the girders was 20 mm. Different widths were used for the bottom flange of the girders.

3. CONCLUSIONS

The fibre reinforced plastic with mixture of carbon fibre and plastic fibre with aluminum nano powder as a filling will increase the strength and stability of the material with more fire resistant and fire retardant property. Less amount of carbon fibre will reduce the cost of the material and thereby we can get the best material at the less cost. Due to the light weight material nearly eight to ten percent weight of the ship will be reduced which will reduce the fuel consumption of the ship and at the same time it will increase the cargo capacity of the ship. Some of the main future research challenges in the field of lightweight construction will be concerned with material properties, robustness of production processes, effective nondestructive inspection, fire performance for FRP composites, and joining methods for aluminum alloys. However when FRPs are exposed to heat, they produce combustible gases which fuel the fire and may lead to failure of the non-combustibility test. The methodology for determining the structural properties and critical temperature at which an FRP structure fails has significant merits. The performance data of the Fibre reinforced plastic super structure may enable the evaluation to focus on performance of an FRP bulkhead which further increases the cargo capacity and less fuel consumption.

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