DESIGN, ANALYSIS AND CHARACTERIZATION OF FIBER REINFORCED PLASTICS FOR REPLACEMENT OF BODY OF GOODS TRAIN WAGON

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ABSTRACT

The current performance requirements for the global rail industry demand that trains are more reliable, efficient and can accommodate an increased capacity for more passengers. The primary objective of the fiber-reinforced composites is to obtain materials with high strength in conjunction with higher elastic modulus. Lightweight construction of rail vehicles is thus required to meet these requirements. A cantilevered seat bracket, luggage rack module, intermediate end structure, body side structure and roof structure were identified by using this frp methodology. Rail car body structural components, forming the primary structure of a rail vehicle, were determined to be the most optimal components to replace in composites for maximum light weighting of the sprung mass. It was estimated that a composite redesign of these components would result in a mass savings of 57% for intermediate end structures, 47% for body side structures and 51% for roof structures. The Kevlar, basalt and glass fiber reinforced plastics are selected and laminates were prepared by using hand lay up technique .Test coupons were prepared as per the ASTM standards and material characterization test were carried in different combinations of the above prescribed fiber plastics. The finite element analysis were carried out by using Ansys Workbench on various combinations of the Kevlar, basalt and glass fiber reinforced polymers.

Keyword : - *Railway wagon analysis, fibre reinforced plastics, basalt fiber, glass fiber, Impact analysis.*

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1. INTRODCUTION

A composite material (also called a composition material or shortened to composite, which is the common name) is a material made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure, differentiating composites from mixtures and solid solutions. Basic requirements for the better performance efficiency of an aircraft are high strength, high stiffness and low weight. The conventional materials such as metals and alloys could satisfy these requirements only to a certain extent. This led to the need for developing new materials whose properties were superior to conventional metals and alloys. A composite is a structural material which consists of two or more constituents combined at a macroscopic level. The constituents of a composite material are a continuous phase called matrix and a discontinuous phase called reinforcement. A composite material is the oldest and best advanced technology of the world. The main advantage of composite material is light lightweight and the fabrication process is easy. Now composites materials are extensively used in automotive, aerospace, marine etc. industry. Since the development of composite material improves the mechanical strength. To fabricate the laminate the main material is epoxy and hardener. To improve the mechanical strength epoxy is added more in aircraft and marine. There are different types of fiber used.The strength of the composite depends on the type of the fiber and Orientation. Materials are classily as isotropic and anisotropic. The isotropic material is in the same direction and loads with the same strains, The direction with anisotropic materials in the load are created with strains and shear strain. Fiber-reinforced composites are essentially axial particulates embedded in fitting matrices. The primary objective of fiber-reinforced composites is to obtain materials with high strength in conjunction with higher elastic modulus. The strength elevation is however affected with applied load transiting from matrix to fibers, interfacial bonding between fiber-matrix, their relative alignment and nature of fiber scheming the overall material behaviors. The alignment of fibers may however be continuous or random depending on the end applications. The choice of the fiber reinforcement and its fitting matrix also depends on application requirements. These are components that the consortium believes to be the most suitable to demonstrate the benefit of a composite replacement in terms of integration potential, light weighting benefits and commercial viability. Furthermore, rail car body structural components, forming the primary structure of a rail vehicle, were determined to be the most optimal components to replace in composites for maximum lightweighting of the sprung mass. It was estimated that a composite redesign of these components would result in a mass savings of 57% for intermediate end structures, 47% for body side structures and 51% for roof structures [2]. Study on the main challenging things in railway vehicles are to reduce the consumption of energy for transportation and to decrease the emission of harmful gasses by limiting the consumption of fuel sources. These drawbacks can be overcome by lightweight structures designed for the vehicle bodies and frameworks. The composite materials with fiber reinforcements are the preferred choice for manufacturing lightweight structures to reduce the overall weight of the rail vehicle. The fiber reinforced polymer (FRP) materials possess light-weightiness, high strength, high stiffness value and are more durable in nature. The researchers are continuously putting their efforts into new innovations in concern towards the replacement of existing conventional materials by FRP composites in railway applications. Moreover, the challenges are quoted in this review through the comprehensive analysis of literature and hence it provides the information in the form of research gaps, so that it would be helpful for the researchers to overcome all the challenges in their upcoming research works [3]. There has been an increasing interest in seeking the potential applications of recycled mixed plastic wastes in building and construction sectors to relieve the pressure on landfills. This paper presents the recent developments and applications of composite materials made from recycled mixed plastics and glass fiber. Some of the first uses for such composites are as an alternative to non-load bearing applications like park benches and picnic tables. With its inherent resistance to rot and insect attack, these composites can in fact be used as a replacement for chemically treated woods in various larger-scale outdoor applications such as railroad crossties and bridges. The paper identifies research needs critical in the effective design and utilization of these composite materials in civil engineering and construction [4]. The primary use of fiber-reinforced composites in automobiles, with the exception of a few specialized low volume vehicles, has been in semi-structural or decorative parts. Use of composites in primary structural areas of the vehicle, such as body structures, has been very limited to date. Such applications offer a tremendous opportunity for future expansion of composites in the automotive industry. The less quantifiable, but equally important, functional requirement of ride quality (usually defined in terms of noise, vibration and ride harshness, NVH) also appears to be attainable through the utilization of composites. Even though this factor has been historically related to vehicle stiffness, and composite materials are less stiff than steel, all the indications are that the effective stiffness of composite structures meet NVH requirements—the elimination of joints through part integration plays a critical role in achieving such synergistic effects [5].

2. PROBLEM IDENTIFICATION

The present work investigates the fabrication of Kevlar/epoxy and basalt/epoxy and Kevlar/basalt/epoxy hybrid composite laminates and compares their mechanical properties. Mechanical characterization tests, including tension, flexural, impact and hardness tests, as per ASTM standards, were conducted on coupons cut out from the fabricated composite panels. A hand layup fabrication technique was used to fabricate composite panels with seven layers in them. Eight such laminates, with two containing pure Kevlar/epoxy and basalt/epoxy and the remaining ones containing Kevlar/basalt, were stacked in different sequences and impregnated in an epoxy matrix to provide a hybrid configuration. The microscopic examination of the fabricated laminates revealed that there was good bonding between the reinforcements and matrix material. Out of the eight composite panels including the hybrids, the ones with the pure basalt/epoxy exhibited more tensile and flexural strength than its Kevlar/epoxy counterpart due to its higher density value. This makes the rooftop or any other material on train wagon to turns into composite and reduce weight without any negligence in strength.

3. MATERIAL SELECTION

The materials are generally selected based on the requirement of the application. The materials used are bi directional woven fabrics of glass fiber, basalt fiber and Kevlar fiber. The resin used is epoxy resin.

3.1 Kevlar fibre

Kevlar is a fiber with incredible strength. Thanks to the way the fiber is manufactured using inter-chain bonds (imagine woven fibers at a microscopic level), alongside cross-linked hydrogen bonds that adhere to these chains (imagine small fibers that span across the surface of those woven fibers, creating a mesh), Kevlar has an impressive tensile strength. In fact, Kevlar is over ten times stronger than steel in tensile strength, pound for pound. Kevlar also has excellent heat resistance, flexibility, ballistic resistance, and cut/puncture resistance

Fig -1 : Kevlar woven fabric

3.2 Basalt fibre

Basalt fiber is a continuous fiber made of melting basalt stone at 1450 to 1500 degrees through Platinum rhodium alloy bushing. It is a new environmental protection fiber which is known as the twenty-first Century 'volcano rock silk', it is also called golden fiber because its color is golden brown.Basalt fiber reinforced bar is made of high strength basalt fiber and vinyl resin (epoxy resin) by spinning, winding, surface coating and compound molding. It is a new building material with the characteristics of high strength, excellent acid and alkali resistance and durability. Its hardness is 3 times of steel bar, and the density is only about 1/4 of steel bar.

3.3 Glass fibre

Glass fibers are formed from melts and manufactured in various compositions by changing the amount of raw materials like sand for silica, clay for alumina, calcite for calcium oxide, and colemanite for boron oxide. Glass fiber products are classified according to the type of composite at which they are utilized. Moreover, chopped strands, direct draw rovings, assembled rovings, and mats are the most important products that are used in the injection molding, filament winding, pultrusion, sheet molding, and hand layup processes to form glass fiber-reinforced composites. Protection of the glass fiber filaments from breakage or disintegration is an important issue either during manufacturing of glass fiber or during composite production. The resultant interphase layer can either increase or decrease the performance of the composite considering harmony between sizing components and matrix polymer.

Compatibility between sizing and matrix polymer enhances high mechanical properties and on the contrary incompatible sizing results in poor mechanical properties.

4. FABRICATION OF TEST COUPONS

The fabrication process is carried out by the hand lay up method. The resin used for the fabrication process is epoxy resin. The glass fiber laminates, Kevlar fiber laminates and basalt fiber laminates are prepared. The test coupons were fabricated by the size of 300 x 300 mm. The fiber and matrix ratio was maintained as 1:1 ratio. The Mylar sheet was used as platform for fabrication to obtain the proper finishing. The individual laminates were dried up for 24 hours as the curing time.

Fig -2: Kevlar fiber laminate

Fig -3: Basalt fiber laminate

Fig -4 : Glass fiber laminate

4. MECHANICAL CHARACTERIZATION

The mechanical characterization in fiber reinforced laminates is used for determining the mechanical properties of the fiber laminated plastics. The tests generally conducted are tensile test, flexural test and impact test. The test coupons are prepared based on the ASTM standards.

4.1 Tensile test

Tensile Testing is a form of tension testing and is a destructive engineering and materials science test whereby controlled tension is applied to a sample until it fully fails. This is one of the most common mechanical testing techniques. It is used to find out how strong a material is and also how much it can be stretched before it breaks. This test method is used to determine yield strength, ultimate tensile strength, ductility, strain hardening characteristics, Young's modulus and Poisson's ratio.

4.2 Flexural test

Flexural strength, also known as modulus of rupture, or bend strength, or transverse rupture strength is a material property, defined as the stress in a material just before it yields in a flexure test. The transverse bending test is most frequently employed, in which a specimen having either a circular or rectangular cross-section is bent until fracture or yielding using a three point flexural test technique.

5. NUMERICAL SIMULATION

ANSYS Workbench is a project-management tool. It can be considered as the top-level interface linking all our software tools. Workbench handles the passing of data between ANSYS Geometry / Mesh / Solver / Post Processing tools. This greatly helps project management. You do not need to worry about the individual files on disk (geometry, mesh etc). Graphically, you can see at-a-glance how a project has been built. Because Workbench can manage the individual applications AND pass data between them, it is easy to automatically perform design studies (parametric analyses) for design optimization.

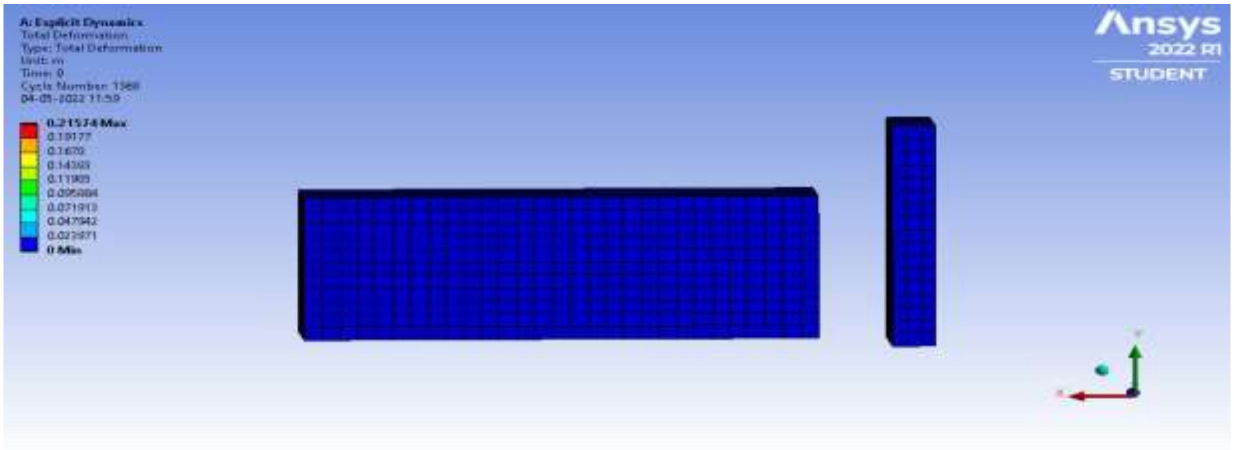

Fig -5: Steel before impact

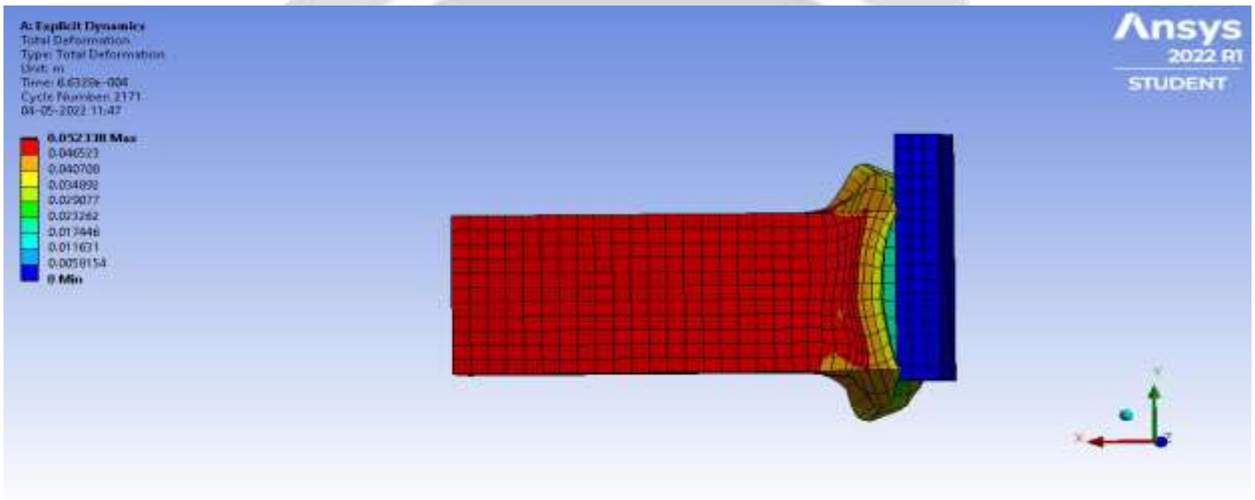

Fig -6: Glass fiber after impact

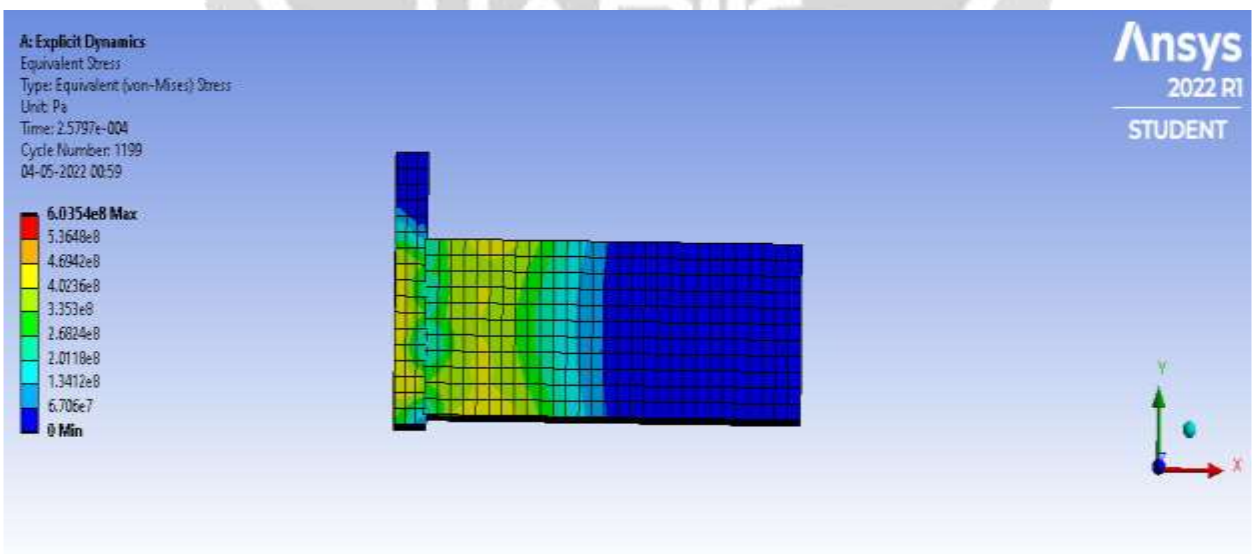

Fig -7: Kevlar fiber after impact

6. CONCLUSION

The need of the fiber reinforced polymer has become more inevitable in the recent years in the application of less weight and high strength. The proposed work is based on the implication of it. The rail wagon body is replaced by the fiber reinforced polymers to increase the functional attributes of the rail wagon body and to reduce its weight. Numerical investigation has been carried out by using Ansys workbench software. Different orientations of the basalt fiber, glass fiber and Kevlar fiber have been developed by using the hand lay up techniques. The rail wagon body is designed by using Creo parametric and then incorporated into the workbench software by converting it into an IGES file format. The mechanical characterization tests reveals that the Kevlar/glass sandwich laminates gave better tensile strength, flexural strength and impact strength when compared to the other combinations like basalt/glass sandwich laminates. The impact analysis result also revealed that the Kevlar/glass laminates gave better impact strength when compared to the other combinations even at high speeds of collisions.

7. REFERENCES

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