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ANALYZING MECHANICAL PROPERTIES OF SYNTHETIC FIBERS COMPOSITES WITH CARBON POWDER REINFORCEMENT

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Abstract: Many researchers are searching for structural materials of high strength, less weight and low cost. In generally strong materials are relatively density and light materials have less strength. In order to achieve high strength and less weight, we go for composite materials. Then the tensile strength and impact strength of specimens is determined using ultimate testing machine and impact testing machine. This study investigates the mechanical properties of composite materials by incorporating various fibers, namely S-Glass, Aramid and Nylon, each combined with a 10% addition of carbon powder. Additionally, hybrid combinations of these fibers such as S-Glass + Aramid + 10% Carbon Powder, Aramid + Nylon + 10% Carbon Powder, Nylon + S-Glass + 10% Carbon Powder and Nylon + S-Glass + Aramid + 10% Carbon Powder are explored. Polyester-resin is utilized as the matrix material to form the composite specimens, adhering to ASTM standards. The research focuses on evaluating the mechanical performance of the composite materials through comprehensive testing methods. Tensile Strength, Flexural Strength, Impact Strength, and Hardness are examined to assess the material's overall robustness. Scanning Electron Microscopy (SEM) is employed to study the microstructure of the composites, providing insights into the distribution and interaction of the fibers within the matrix. Furthermore, the study extends to practical applications by analyzing car bumper made from the composite materials. A static analysis is conducted to determine Von-Misses stress, total deformation. This analysis aids in understanding how these materials perform under real-world conditions, specifically in scenarios relevant to automotive applications. The outcomes of this research contribute valuable insights into the potential enhancements in mechanical properties achieved by incorporating different fibers and carbon powder in composite materials. The findings offer guidance for optimizing the composition of hybrid fiber-reinforced polymers for applications demanding high strength and impact resistance, such as automotive components.

I. INTRODUCTION TO FIBERS

A composite material is essentially a blend of two or more distinct components, each retaining its individual properties at a visible level. These components, known as the reinforcing phase and the matrix, are intermixed to form a unified structure. The reinforcing phase, which can take the form of fibers, particles, or flakes, serves to enhance specific properties of the composite. Meanwhile, the matrix, typically in a continuous form, surrounds and supports the reinforcing phase. Examples of composite systems abound, such as concrete fortified with steel and epoxy reinforced with graphite fibers. These combinations offer tailored properties, leveraging the strengths of each constituent to create materials with diverse applications across industries. The technological development has increased on advances in the materials field. Fibers possess a range of properties that make them valuable for various applications.

COMPOSITE

Composite comprises of different materials with distinct properties to create a superior and unique material. Composites are grouped by reinforcement or by types of matrix in which reinforcements are load carrying element whereas matrix material help them to keep in desired location and become load transfer medium between reinforcement and matrix. Fiber reinforce composites are gaining interest in various application, but their growth is limited due to toughness. Hybridization of fiber is an approach to make composites toughen by combining different kind of fiber and these hybrid composites offer good mechanical properties compare to non-hybrids composites. Mingling of fiber in unit matrix, hybrid fiber reinforced composites offer wide range of mechanical properties.

II. LITERATURE REVIEW

[1] The purpose of this research is to establish stab proof material made up of shear thickening fluid (STF) and Aramid fiber. In this research, silica / ethylene glycol suspension was prepared for the use as STF and it was evaluated by rheometer. From the results, it was seen that STF exhibited a reverse liquid- solid transition at a particular shear. Aramid was treated as STF by 1 dip 1 nip method and mechanical and stab resistant properties were analyzed. After viewing both the results, STF impregnation comprehensively upgraded the stab resistance of Aramid against the spike threats and the safety aspect of Aramid was also increased comprehensively. [2] The stab resistant coating was performed by considering one STF, fumed silica / ethylene glycol suspension of Aramid fabric to enhance the performance of the material. From this research, extensive upgrades in puncture defiance were seen especially in excessive speed loading condition. It was seen that the addition did not change or deteriorate the flexibility of STF. From the results, we incurred that fumed silica/ Aramid composite fabric would be a fine material for body armored applications [3] Moreover, multiple materials that are combined to produce an individual component. The two materials that were investigated were Aramid poly (p-phenylene terephthalamide) and santoprene. Here in this investigation, the Aramid fiber was used in two ways, the first type was, it was used without altering it and the second type was used after altering it.

[4]The Aramid which was used without modifying strengthened the santoprene to quote an extent and it upgraded few properties of the composite, namely low strain modulus and tensile strength but it also had a drawback, lengthening at break reduced heavily. In order to overcome this, the Aramid was modified and hence its surface was hydrolyzed maleic anhydride-grafted polypropylene (MA-g-PP). There were clear advantages of using the modified Aramid over the stock one. The properties enhanced and the drawbacks were reduced to nil. This combination showed improved stress distribution due to better surface bonding between the fiber and matrix**.** [5] Thereafter, Fluorinated and Oxy fluorinated Short Aramid Fiber-Reinforced Ethylene Propylene Polymer This paper examines raw Aramid and surface treated Aramid. Examination on its thermal properties showed an increase in thermal stability and storage modulus due to gradual reinforcement of fibers. It is also noted that it continues to increase in the case of ox fluorinated and fluorinated Aramid fiber-reinforced EP.

III. MATERIALS USED

NYLON FIBER

Nylon fiber is composed of Nylon atoms bonded together to form a long chain. The fibers are extremely stiff, strong, and light, and are used in many processes to create excellent building materials. Nylon fiber material comes in a variety of "raw" building blocks, including yarns, uni-directional, weaves, braids, and several others, which are in turn used to create Nylon fiber composite parts.

ARAMID FIBER

Aramid has many applications, ranging from bicycle tires and racing sails to bulletproof vests, all due to its high tensile strength-to-weight ratio; by this measure it is five times stronger than steel. It also is used to make modern marching drumheads that withstand high impact

S GLASS

Chopped strand mat is a non-woven reinforcement fiber for the production of fiber-reinforced plastic.

Product properties:

- Even thickness and distribution of fibers
- High plasticity and resin impregnation properties
- Good mechanical properties and Easy to cut

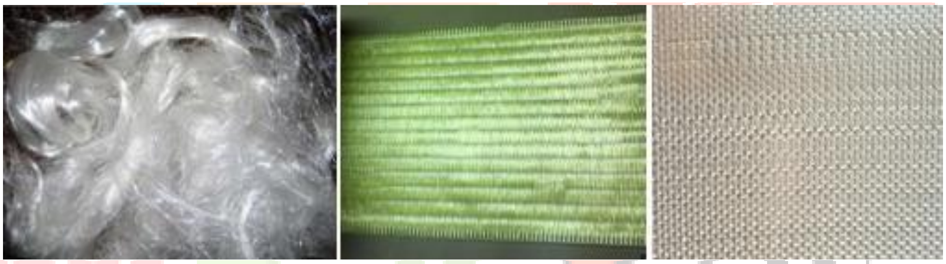


Figure (i) Nylon fiber (ii) aramid fiber (iii) S glass fiber

EPOXY

In present work epoxy LY556 is used as matrix material shown in figure.3.1 to fabricate hybrid fiber epoxy composites. Epoxy LY556 is chosen because it is a one such matrix which is extensively used because it exhibit low shrinkage, higher mechanical properties, easy fabrication, excellent chemical and moisture resistance, good wet ability. Epoxy resins are the most commonly used thermo set plastic in polymer matrix composites. Epoxy resins are a family of thermo set plastic materials which do not give off reaction products when they cure and so have low cure shrinkage. They also have good adhesion to other materials, good chemical and environmental resistance and good insulating properties.

HARDENER

Hardener used for present investigation for initiating gel formation is hardener HY951 which is shown in figure.3.2. The combination of epoxy LY556 and hardener which cures at room temperature, excellent adhesive strength, good mechanical and electrical properties. The ratio of the epoxy and hardener are taken 10:1 that is 10 grams of epoxy and 1 gram of hardener..

Figure Epoxy Resin LY556 Hardener HY 951

CARBON POWDER

Carbon powder fibers, also known as carbon fiber powder or carbon nano fibers are highly desirable materials due to their exceptional mechanical, electrical, and thermal properties. They are widely used in various industries, including aerospace, automotive, sports equipment, and electronics.


Figure Carbon powder

IV. HAND LAYUP PROCESS

Hand lay-up technique is the simple and cheapest method of composite processing. The infrastructural need for this technique is also minimal. The standard test procedure for Mechanical properties of fiber-resin composites; ASTM-D790M-86 is utilized to according to the measurements. The mold is prepared on smooth clear film with 2-way tape to the required measurement. At that surface mold is prepared keeping the 2-way tape on the clear film.

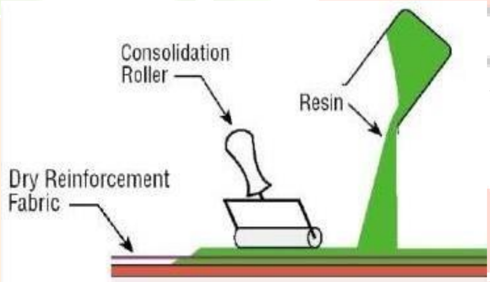


Figure Schematic diagram of Hand Lay-up process

After fabrication specimens are cut form sheets according to the ASTM standards 165mm*19mm*4mm in thick are fabricated for tensile testing dimensions are taken. 200mm long, 20mm width and 5 mm in thick are fabricated for flexural testing. 55 mm long, 12.5mm width and 4 mm thick are fabricated for impact testing. 25 mm long, 25 mm width and 5 mm thick are fabricated for hardness testing.

COMPOSITIONS TAKEN:

- S-Glass +10% Carbon Powder
- Aramid +10% Carbon Powder
- Nylon +10% Carbon Powder
- S-Glass + Aramid + 10% Carbon Powder
- Aramid + Nylon + 10% Carbon Powder
- Nylon + S-Glass + 10% Carbon Powder
- Nylon + S-Glass + Aramid + 10% Carbon Powder

V. TESTINGS

TENSILE TESTING OF COMPOSITES

A 2-ton limits electronic tensometer which is shown in figure 3.13, METM 2000 ER-1 model (Plate II-18), supplied by M/S micro teach Pune, is used to determine the elasticity of composites. Its capability can be changed by burden cells of 20 kg, 200 kg and 2 ton. A burden cell of 2 ton is used for testing composite specimens. Self-adjusted brisk grasp throw is used to hold composite specimens. A computerized micrometer is used to measure the required thickness and width of composite specimens.

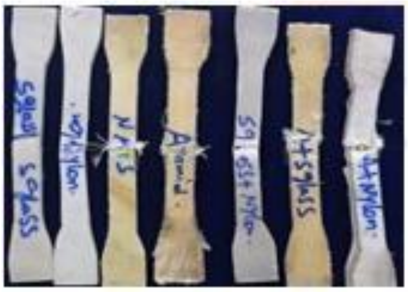


Figure testing tensile strength materials specimens

The tensile stress are determined by the following relation

$$\textbf{Tensile stress } \sigma_t = \frac{\textit{tensile load}}{\textit{area of cross-section}}$$

$$= \frac{P}{A} \text{ N/mm}^2$$

TENSILE STRENGTH

Fabrication and testing successfully completed in this project the tensile properties of Aramid, Nylon fiber, S glass, Aramid/Nylon fiber, Aramid/Nylon fiber/S glass, Aramid/S glass & Nylon fiber/S glass 10% of carbon powder fabricated by using hand lay-up method. After successful completion of the tensile strength we are getting maximum values for the ARAMID/S glass/Nylon with 10% of carbon powder at 12750 N.

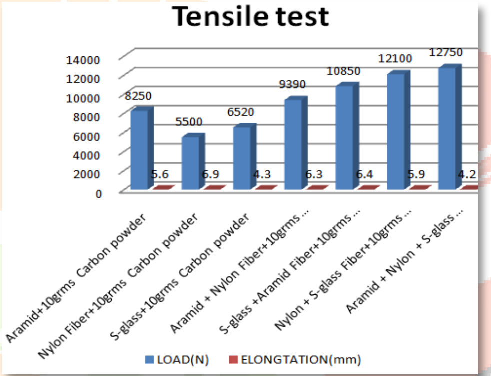


Figure tensile test result graph

FLEXURAL TESTING OF COMPOSITES

Three point bowing test are carried out as per ASTM-D790M-86 test procedure 1, system A to extract flexural properties, the specimens are 200mm long, 20mm width and 5 mm in thick are fabricated for flexural testing thick are fabricated for flexural testing. Two indistinguishable specimens are subjected for flexural testing. In three point bowing test, the external rollers are 70 mm separated and specimens are subjected at a strain rate of 0.2 mm/min.

Figure flexural strength specimens of all materials Flexural stresses are determined by the following relations.

$$\textbf{Flexural stress S} = \frac{3PL}{2bt^2}$$

P= load in N

L= length between supports (70mm) b= Width in mm

d= Thickness in mm

FLEXURAL STRENGTH

Fabrication and testing successfully completed in this project the flexural strength of Aramid, Nylon fiber, S glass, Aramid/Nylon fiber, Aramid/Nylon fiber/S glass, Aramid/S glass & Nylon fiber/S glass with 10% of carbon powder are fabricated by using hand lay-up method. Based on the flexural strength finally concluded that ARAMID/S glass/Nylon with 10% of carbon powder at 1320 N high flexural strength compared to remaining composites.

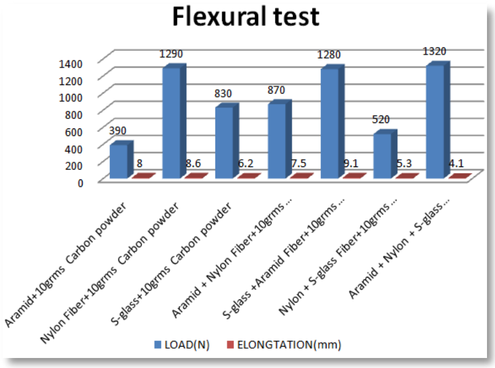


Figure Flexural test result graph

IMPACT TESTING OF COMPOSITES

Impact test is also known as charpy v notch, Impact tester was sway analyzer supplied by M/S International Equipment's, Mumbai, was used to test the impact properties of fiber Reinforced composite specimen. 55 mm long, 12.5mm width and 4 mm thick are fabricated for impact testing. Standard test procedure, ASTM D256-97, for effect properties of fiber composites has been used to examine the unidirectional composite specimens. The specimens to be examined are of dimensions 55 mm long, 12.5mm width and 4 mm thick are fabricated for impact testing. A V-point is placed in impact tester record having an included point of 450 at the focal point of the specimen, and at 90¬¬0 to the specimen pivot. The profundity of the specimen to be examined under the indent is 2 mm.

Figure impact strength specimens of all materials The examination Impact strength was calculated by the following relation

$$\sigma = \frac{2P}{A}$$

P= Energy observed in J A= Area in mm

IMPACT STRENGTH

Fabrication and testing successfully completed in this project I also focused on impact strength of Aramid, Nylon fiber, S glass, Aramid/Nylon fiber, Aramid/Nylon fiber/S glass, Aramid/S glass & Nylon fiber/S glass with 10% of carbon powder fabricated by using hand lay-up method. And finally concluded the ARAMID/S glass/Nylon with 10% of carbon powder hybrid material possess high impact strength compared to remaining compositions

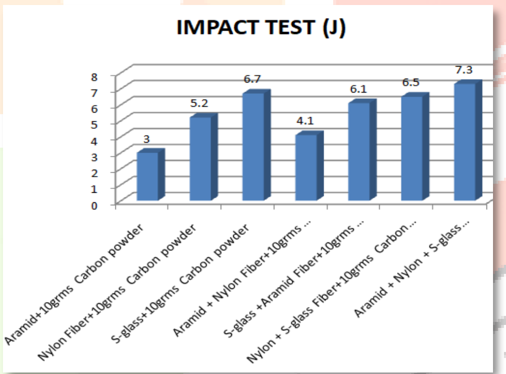


Figure Impact strength result graph

HARDNESS TEST

Hardness properties According to ASTM D 785 standards for composites, the specimens were prepared for Rockwell-B hardness test, the specimen is of 25mm diameter and a length of 25mm.

Specimens before & after hardness testing

HARDNESS NUMBER:

Brinell hardness values of these natural composites. Experiment gives the ARAMID/S glass/Nylon with 10% of carbon powder having maximum Brinell hardness value. Brinell hardness vs. experiment number graph of the composite. Figure reveals the graph indicating Brinell hardness values corresponding to the experiment number. The graph shows, experiment with Aramid/Nylon fiber/S glass with 10% of carbon powder gives the higher value of Brinell hardness number as 152.

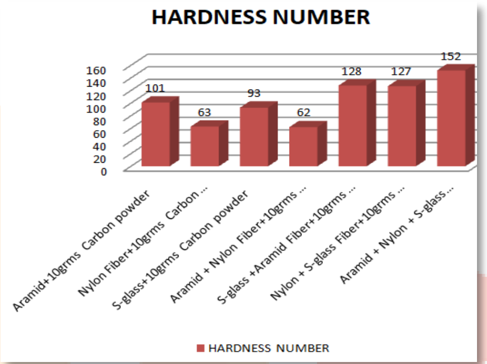


Figure Hardness number result graph

SEM ANALYSIS:

Applications of SEM analysis are widespread and diverse, ranging from materials science and metallurgy to biology, geology, forensics, and nanotechnology. Researchers and engineers utilize SEM to investigate the microstructure of materials, analyze particle size and distribution, characterize surface coatings, study biological samples, examine semiconductor devices, and much more.

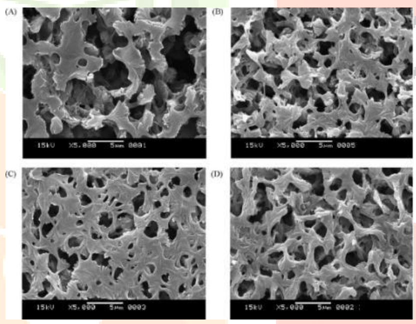


Figure the SEM micrographs of the plain s glass/nylon/aramid membrane and affinity membrane: (A) plain nylon membrane, 5000×; (B) plain s glass membrane, 5000×; (C) plain aramid membrane, 5000×; (D) s glass/nylon/aramid membrane, 5000×.

VI. DESIGN PROCEDURE IN CATIA:

Modeling of Car Bumper by Catia – Software application within the CAD/CAD/CAM/CAE category, along with other similar products currently on the market. Creo/Engineer is a parametric, feature-based modeling architecture incorporated into a single database philosophy with advanced rule-based design capabilities .The capabilities of the product can be split into the three main heading of Engineering Design, Analysis and Manufacturing. This data is then documented in a standard 2D production drawing and the 3D modeling of car bumper is done with help of catia - software and dimensions are selected from one of car bumper. Design dimension of Maruti Suzuki Alto car bumper same for first design called as existing bumper design. As the impact is more for the front portion of bumper only outer dimensions of car bumper has been considered, Slots provided in middle of car bumper is used for reducing drag effect in car bumper.

Figure isometric model of car bumper

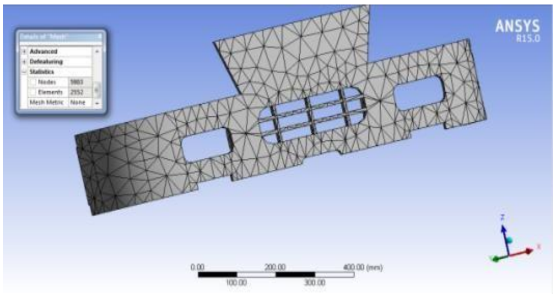


Figure Mesh: Nodes: 5983, Elements: 2552

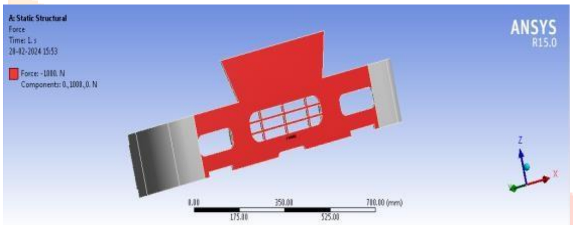


Figure Boundary conditions 1000 N

VII. SIMULATION IN ANSYS:

ANSYS ONEXISISTING POLY CARBONATE MATERIAL:

Poly carbonate is the generally used existing car bumper model was analyzed using Structural analysis of ANSYS and finally concludes the best among Von-misses stress and Total deformation of Polycarbonate

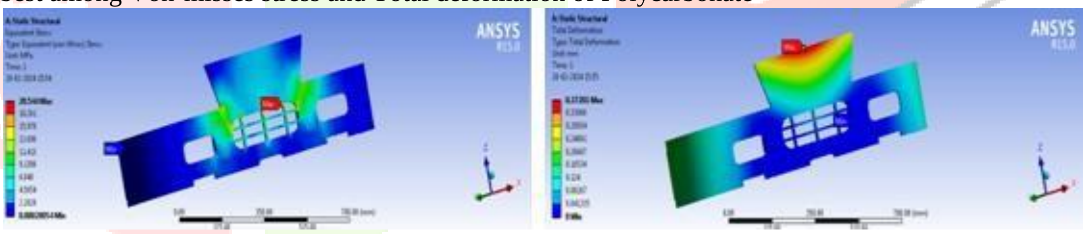


Figure Von-misses stress and Total deformation of Polycarbonate

ANSYS ON PROPOSED NYLON+ARAMID+SGLASS+10% CARBON POWDER COMPOSITE:

Nylon+aramid+sglass+10% carbon powder is the proposed fiber composite used existing car bumper model was analyzed using Structural analysis of ANSYS and finally concludes the best among Von-misses stress and Total deformation of Polycarbonate

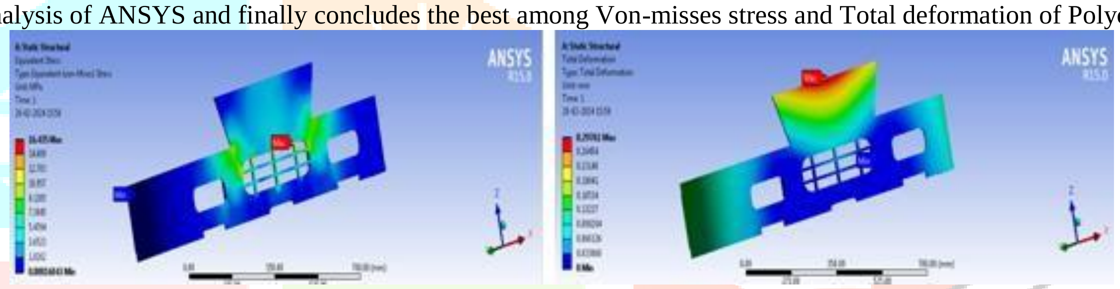
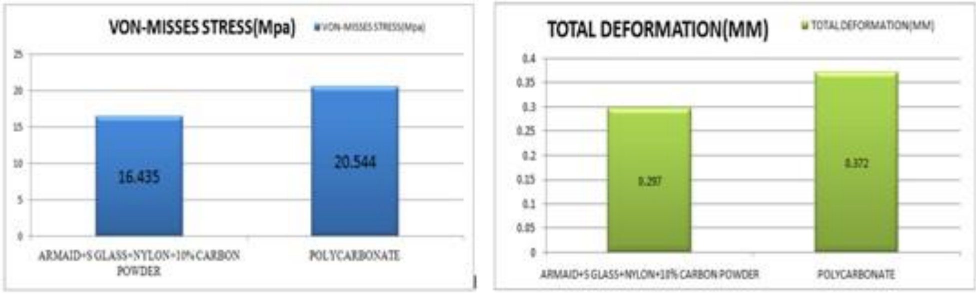


Figure Von-misses stress and Total deformation of composite

GRAPHS:

The static structural analysis between the existing car bumper material Polycarbonate and proposed nylon+aramid+sglass+10% carbon powder material has been analyzed and finally getting best von misses stress results for the nylon+aramid+sglass+10% carbon powder of 16.435 MPa among the other as 20.544 MPa



Graphs Von-misses stress Total deformation graphs

The static structural analysis between the existing car bumper material Polycarbonate and proposed nylon+aramid+sglass+10% carbon powder material has been analyzed and finally getting best total deformation results for the nylon+aramid+sglass+10% carbon powder of 0.297 mm among the other as 0.372 mm

VIII. CONCLUSION

The present work has been done with an objective to explore the use of ARAMID with 10% of carbon powder, Nylon fiber with 10% of carbon powder, S glass with 10% of carbon powder, ARAMID /Nylon fiber with 10% of carbon powder, ARAMID /Nylon fiber/S glass with 10% of carbon powder, ARAMID /S glass & Nylon fiber/S glass with 10% of carbon powder, are manufactured using hand lay-up method. Epoxy is used as matrix in the reinforced composite and investigated the mechanical properties like tensile, flexure, impact, hardness and SEM number of composites. This work is focused to find the best composite among the seven combinations. After all the tests has performed on the specimens the ARAMID /S GLASS/NYLON WITH 10% OF CARBON POWDER, shows a best result in the tensile strength ,SEM, impact strength, hardness test and as well as flexural strength. On design and analysis of car bumper with existing poly carbonate material and proposed material of von misses stresses and total deformation values are favorable for the proposed ARAMID /S GLASS/NYLON WITH 10% OF

CARBON POWDER. For the above investigations we are proposed the ARAMID WITH NYLON FIBER AND S GLASS WITH 10% OF CARBON POWDER, having good mechanical properties when comparing with other results.

FUTURE SCOPE

The extension of this thesis work can be done by considering the following points:

- The fibre can also take in the form of powder to fabricate the specimen which may increases the strength.
- Different type reins can be used to find the mechanical properties like strength, wear resistance
- By considering different process parameter and different composites which improves the properties of composites.

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