Impact studies on polymer composites under different curing methods: A Review

Siddappa Balappa Makani [1], P. Kiran Kumar[2], Shankara. D. R[3], T. Madhusudhan[4]

[1]P.G. Scholar, Dept. of Mechanical, SJB Institute of Technology, Bengaluru, Karnataka, India.

[2]Professor, Dept. of Mechanical, SJB Institute of Technology, Bengaluru, Karnataka, India.

[3]Asst. Professor, Dept. of Mechanical, SJB Institute of Technology, Bengaluru, Karnataka, India.

[4]Professor, Dept. of Mechanical, SJB Institute of Technology, Bengaluru, Karnataka, India.

Abstract – *The paper works describes the development of impact behavior of different material of polymer composites under different curing methods with glass fiber, jute fiber and epoxy resin. Izod and charpy impact test were performed to determine the dynamic impact strength of the specimens. The results show that curing of the specimens exhibits the better impact strength and low cost and high-coeffient curing strategy for manufacture of advanced polymer composites is of extraordinary scholastic and industrial interest and aerospace.*

Key Words: Composite materials, Izod impact energy; Charpy impact energy, Glass fibers, Jute fibers and Epoxy.

1. INTRODUCTION

The term composite can be characterized as a material made out of two or more diverse material, with the properties of the resultant material being better than the properties of individual materials that make up the composite. In the recent year's one of the primary classes of superior engineering material, next to metals and its combinations, ceramics and polymeric materials are composite materials. These designing materials are prepared by two separate substances. In prepared composite, these different materials are associated with interface layer coupling two immiscible stages matrix and reinforcement or filler. The reinforcement material gives the mechanical quality and transfer load in the composite. The matrix binds and maintains the alignment or support material and protects the reinforcement from abrasion or the environment. Then the composite material can be classified into three types. Those are metal matrix composites (MMC´s), ceramic matrix composites (CMC´s) and polymer matrix composites (PMC´s) also called as reinforced polymers (or plastics). Composite materials commonly used in the structural components, engineering applications, aerospace, automotive, defense and sports industries because composite materials have superior specific properties such as high strength and stiffness to weight ratio, improved corrosion and environmental resistance, design flexibility, improved fatigue life, potential reduction of processing, fabrication and life cycle cost.

1.1 MATERIALS

Glass fibre

Glass fiber is a material comprising of various to a great degree fine strands of glass. Glass fibre types are E-glass, A-glass, C-glass, R-glass and E-CR-glass. Out this type most commonly used glass fibre is E-glass. Glass fiber when utilized as a thermal protecting material, is uniquely made with a holding specialist to trap numerous little air cells, bringing about the naturally air-filled low-thickness "glass wool" group of items. Glass fiber has generally equivalent mechanical properties to different strands, for example, polymers and carbon fiber and it is much less expensive and altogether less weak when utilized as a part of composites. Glass fibre used in the automobile industries, boat hulls, aerospace and hockey sticks.

Jute fibre

Jute is known as the 'Golden Fibre' due to its golden brown colour and its significance. As far as use, generation and worldwide utilization, jute is second just to cotton. It is the fiber used to make hessian sacks and garden twine. Jute is naturally neighborly and also being a standout amongst the most reasonable strands; jute plants are anything but difficult to develop, have a high return for every section of land and, not at all like cotton, have little requirement for pesticides and composts. Jute is a bast fiber, similar to flax and hemp, and the stems are handled similarly.

Resin

The resins that are utilized as a part of fiber reinforced composites are now and again reffered to as 'polymers'. All polymers display an important regular property in that they are formed of long chain-like particles comprising of numerous straightforward rehashing units. Synthetic polymers are for the most part called 'synthetic resins'. Polymers can be ordered under two sorts, "thermoplastic" and 'thermosetting', as indicated by the effect of heat on their properties. The different types of resins are Polyester Resins, Vinylester Resins and Epoxy Resins. Epoxies for the most part out-perform most other resin types in terms of mechanical properties and resistance to environmental degradation, which prompts their practically selective use in aircraft components. The resins used in the composites required following properties are good mechanical properties, good adhesive properties, good toughness properties, good resistance to environmental degradation.

1.2 SPECIMEN PREPARATION

Hand lay-up technique is the simplest and common method of composite processing. First of all, a release gel is sprayed on the mold surface to avoid the adhering of polymer to the surface. Resins are impregnated by hand into filaments which are as woven, sewed, sewed or fortified fabrics. This is typically refined by rollers or brushes, with an expanding utilization of nip-roller sort impregnators for constraining pitch into the fabrics by method for turning rollers and a bath of resin. Laminates are left to cure under standard barometrical conditions. Commonly used resins are epoxy, polyester, vinyl ester and phenolic. Any fibres can be used to prepare the laminate.

2. LITERATURE REVIEW

M. Kwak, et.all[1]: They investigated the curing of composite materials using the recently developed hephaistos microwave. Electromagnetic vitality has been utilized for some a long time for modern applications, including wood drying and bread preparing. There are a few courses in which electromagnetic vitality can be connected, for example, instigation, radio-recurrence (RF) or microwave. The principle distinction is the recurrence at which these strategies work. In spite of the fact that RF and microwave work in a comparable way, microwaves can offer better consistency. Be that as it may, both RF and microwave are generally restricted to dielectric materials with particular dipolar properties. With altered recurrence microwaves, there has been restricted advancement in terms of microwave gear, limiting its utilization in industry, hence microwave innovation is considered to be wrong for generally applications. The two fundamental obstructions for microwaves being embraced in the composites preparing industry are its powerlessness to evade 'problem areas' (i.e. uneven microwave circulation), and the failure to process carbon fiber strengthened polymers (CFRPs) without arcing. Variable recurrence microwave (VFM) gadgets have beat these two troubles, however their high fetched remains a noteworthy boundary.

E. Ciecierska, et.all[2]: They investigated the effect of curing parameters on dispersion and electrical conductivity of epoxy/cnt composites define by image analysis. In this work epoxy pitch EPON 862 supplied by Hexion was utilized. As curing specialists EPICURE W for high temperature curing and TETA for room temperature curing were connected individually. Two sort of CNTs supplied by Nanocyl were connected. In this work impact of curing parameters of nano composites on carbon nanotubes scattering was decided. After effects of picture investigation as figured coefficient of variety of Zones of Influence were outlined with the electrical conductivity. It was found that better scattering is watched for composites cured at room temperature. Be that as it may, higher electrical conductivity was found at higher temperature of curing. It is because of various sort of curing specialists and changes of cross linking thickness. For composites with carbon nanotubes altered with NH2 bunches conveyance of Zones of Influence varies from non-altered CNTs. Better scattering was gotten for composites cured at higher temperature, and in addition higher electrical conductivity was watched. CNTs changed with amino gatherings is by all accounts better scattered at 130°C in light of the conceivable response of epoxy gatherings with epoxy bunches in the high temperature. It acquires uniform scattering. Be that as it may, higher electrical conductivity for this sort of CNT is brought about not just because of better scattering additionally because of use of various curing operators.

Freddy y, et.all[3]: They investigated the electromagnetic radiation curing of an epoxy/fibre glass reinforced composite. One of the fundamental hindrances in the utilization of thermoset lattices for fortified composites structures furthermore, segments is the long time (hours) required for a warm curing procedure to be completely accomplished. Whilst quicker curing room temperature cured frameworks can be utilized, however these frameworks regularly have a quick unconstrained gel time (along these lines constraining the season of lay-up extensively), a short pot lives furthermore, deliver segments frequently with poor mechanical what's more, warm conduct (Gleason, 1983. To guarantee uniform curing all through the composite part, the temperature profile inside the autoclave should likewise be uniform. Utilizing a vacuum packing strategy and an electromagnetic microwave radiation curing prepare, a glass fiber-epoxy grid composite framework has been ideally cured. Ideal curing was accomplished at a essentially quicker time than for a thermally cured process. Flexural qualities accomplished was at any rate as high as that for a warm cure process, whilst the flexural modulus was essentially higher.

Camelia cerbu[4]: He investigated the mechanical characterization of the flax/epoxy composite material. He selected the material are flax woven fabric was used to reinforce a polymer composite material. The different kinds of flax yarns were used on weft and warp direction to manufacture the flax woven fabric. The laminate is prepared by using the hand lay-up technique. The conditioning timing for the laminate was two weeks at room temperature and vacuum system was used to eliminate the voids. The test conducted on the laminate was tensile, flexural and impact tests. The result shows that mechanical properties corresponding to the weft direction of the flax fabric are greater than the warp direction. The young's modulus E is greater on the weft direction than the warp direction. The maximum value of the normal tensile stress is greater in the weft direction than the warp direction. The impact behavior is greater in case of the specimens whose length is parallel with warp direction than the in case of the specimens whose length is parallel to the weft direction.

Mahmood M shokrieh, et.al[5]: They investigated that the dynamic failure behavior of glass/epoxy composites under low temperature using charpy impact tests method. The material used is E-glass fibers is a reinforcement material, While epoxy resin has been considered as matrix material. E-glass fiber reinforced epoxy as used to prepare the laminate with quasi-isotropic stack sequence. For this reason hand lay-up method was used to prepare the laminate. Finally conclude that the impact energy decrease with decrease of the test temperature and specimens after 10 days exposure to low temperature shows slightly lower impact energy adsorption. Result shows that the impact strength decreases by increasing the specimens span length. This may result in significant increase in mechanical properties of composites at low temperature under static loading but the impact response of composites reduced by decreasing temperature.

Camelia cerbu, et.al[6]: This paper describes the impact behavior of the composite materials randomly reinforced with E-glass fibers. The material used is E-glass fibers were used to randomly reinforce four kinds of resins two polyster resins (Heliopol 8431ATX, polylite 440-M880); an epoxy resin (LY 554); a vinyl-ester (ATLAC 582). These materials are used to prepare the laminate through the hand lay-up technique. The laminate is kept in conditioning time was two weeks at room temperature. The notch usually introduced in the material specimens in order to produces the stress concentration and failure in case of the ductile material. Then the specimen is subjected to the charpy test. Result shows that the greater value of the failure energy were measured in case of the composite material is prepared by using the polyster resins and smallest value of the failure energy were obtained in case of the composite manufactured by using the epoxy resin LY554. The final conclusion is to improve the dynamic properties of polymeric composite reinforced with E-glass chopped fibers by using the polyster resins should be used to manufacture the composite material and this paper show that effect of resin type on the dynamic characteristics obtained by charpy test.

Mortas, et.al[7]: Studies analyze the effect of corrosive solution on composite laminates subjected to low velocity impact loading. The material used is ampreg 22 epoxy resins and an ampreg 22 hardener standard, supplied by gurit, was used with 9 layers, all are in the same direction, of woven bi-directional Kevlar and woven bi-directional carbon to produce the all laminates. The system was placed inside the vacuum bag in order to maintain a constant fiber volume fraction and uniform laminate thickness. The vacuum bag remained attached to vacuum pump to eliminate any air bubbles existing in the composite and post-cure is carried out. The composite laminate completely submerged into hydrochloric acid (HCI) and sodium hydroxide (NaoH) at room temperature. Low velocity impact test were performed on the composite laminate by using the drop weight testing machine and also three point bending test done. The impact tests were carried out on different materials after exposure to the HCI and NaoH solutions with several concentrations. Result shows that the alkaline solutions show to be more aggressive than the acid solution, exhibiting the lowest impact performance and residual bending strength. The damaged area was more in the Kevlar/epoxy laminates.

Ramazan Karakuzu, et.al[8]: They investigated the impact characterization of glass/epoxy composite plates by an experimental and numerical study. The material used is glass/epoxy. The unidirectional E-glass fabric was used as reinforcing material. The curing process was carried out by using a hydraulic press with temperature and time control. The impact tests were performed by using fractovis plus test machine at room temperature. The stacking sequence of the impact specimen was chosen as [0°/30°/60°/90°]. The impact tests were performed for three varied parameters. Those are equal impact energy, equal impactor mass and equal impact velocity. Result shows that the effect of equal impact energy, equal impactor mass and equal impact velocity on the maximum contact force, maximum deflection, contact time, absorbed energy and overall damage area of glass/epoxy laminated composite plates were investigated. The conclusion can be drawn from the results obtained is the energy absorption of specimens subjected to equal mass is lower than the specimens subjected to equal velocity. High mass impact causes more delaminations and contact time than low mass impact at equal impact energy except for the penetration case. The delaminations area in the specimen subjected to lower impactor mass with high velocity is lower than the delaminations area in the specimen subjected to higher impactor mass with lower velocity for the same impact energy.

3. CONCLUSIONS

➢ Curing parameters of the epoxy resin have impact for both electrical conductivity furthermore, scattering level of nanofiller in the epoxy lattice. For improvement of electrical and mechanical properties not only kind of nanotubes or dispersion method are important, curing parameters are also increase electrical conductivity in few order of magnitude.

➢ To select a proper curing method, the following criteria, including material, applicability, penetration capabilit, and cost needs to be fully considered.

➢ It has been seen that the mechanical properties of the composites, for example, micro-hardness, tensile strength, flexural strength, impact strength of the composites are additionally significantly affected by the glass fibre.

➢ Material properties and the thickness of the laminates influence the impact dynamics.

➢ The advantages of using composites in aircraft structures are; weight reduction, high corrosion resistance and high resistance to damage from fatigue. These factors play a role in reducing the operating costs of the aircraft in the long term, further improving its efficiency.

➢ Three-dimensional orthogonal woven composites with a perfect geometry have unrivaled effect harm resistance properties.

➢ Low cost and high-proficient curing strategy for manufacture of advanced polymer composites is of extraordinary scholastic and industrial interest, and despite everything it stays as an awesome test and prickly issue.

REFERENCES

[1] M. Kwak, P. Robinson,A. Bismarck, R. Wise. Curing of composite materials using the Recently developed hephaistos microwave. 18th international conference on composite materials.

[2] E. Ciecierska, A. Boczkowska, K. J. Kurzydłowski. Effect of curring parameters on dispersion and electrical conductivity of epoxy/cnt composites define by image analysis. The 19th international conference on composite materials.

[3] Freddy Y. C. Boey and T. H. Lee. Electromagnectic radiation curing of an epoxy/ fiber glass reinforced composite. Radial. Phys. Chem. Vol. 38, NO. 4, pp. 419-423, 1991.

[4] Camelia cerbu. Mechanical characterization of the flax/ epoxy composite material. Procedia technology 19(2015) 268- 275.

[5] Mahmood M Shokrieh, Mohammad A Torabizadeh & Abdolhossein Fereidoon. Dynamic failure behavior of glass/epoxy composites under low temperature using Charpy impact test method. Indian Journal of Engineering & Materials Sciences.Vol. 18, June 2011, pp. 211-220.

[6] Camelia cerbu, vasile ciofoaia ioan curtu, cristina vladuta. Impact behaviour of the composite materials Randomly reinforced with *e*-glass fibres. 13th international research/expert conference "Trends in the development of machinery and associated technology" TMT 2009, hammamet, tunisia, 16-21 october 2009.

[7] N. Mortas, o. Er, p.n.b. reis, j.a.m. ferreira. Effect of corrosive solutions on composites laminates subjected to low Velocity impact loading. Composite structures 108 (2014) 205–211.

[8] Ramazan Karakuzu, Emre Erbil, Mehmet Aktas. Impact characterization of glass/epoxy composite plates: An experimental and numerical study. Composites: Part B 41 (2010) 388–395.

[9] P Kiran Kumar, N V Raghavendra and B K Sridhara. Development of infrared radiation curing system for fiber reinforced polymer composites: An experimental investigation. Indian journal of engineering and materials sciences. Vol. 18, February 2011, pp. 24-30.

[10] dilmurat abliz, yugang duan, leif steuernagel, lei xie, dichen li, and gerhard ziegmann. Curing methods for advanced polymer composites. Article in polymers and polymer composites january 2013.