

Analysis of Impact Damage on Fiber Glass Reinforce Plastic Material

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Abstract- Composites are widely used in many industries such as automobile, aeronautical, sports industry, civil engineering. The drop impact loads critical for aircraft composite components and damaged also produce unlimited defects or failure in the composites. The composites may be damaged due to tensile, compressive, impact force and shear stress on the composite parts. The composites may undergo in service damage due to dropping of tools, Runway debris in aircraft, hailstorm during flying of aircraft and hitting of birds and aircraft. Due to drop impact damage the composite strength decreases drastically this will affect the load carrying capacity and the performance of the material. The finding the damage will not reduce the problem of failures but rectification and repairing may help saving the composite material and saving the lives using the composite material. Here an attempt is carried out to repair the impact damaged composite specimen and increasing strength of damaged composite. The repaired composite experimentally tested for the suitability for further use. The comparison of photo graphic images of good composite specimen and impact repair composite specimen were carried out.

Index Terms- Impact, aircraft, hailstorm, rectification, reinforce, tensile, compressive, shear stress.

INTRODUCTION

Composite materials are found in everything from office buildings to space ships. They are an attractive material for aviation and aerospace applications because of their strength-and-stiffness-to-density ratios. Composite materials consist of combinations of two or more components.

CLASSIFICATION OF COMPOSITES BASED ON MATRIX MATERIAL

- Metal Matrix Composites (MMC):
- Ceramic Matrix Composites (CMC)
- Polymer Matrix Composites (PMC)

FIBROUS COMPOSITES

1. Short-fiber reinforced composites. Short-fiber reinforced composites consist of a matrix reinforced by a dispersed phase in form of discontinuous fibers (length < 100*diameter).
 - Composites with random orientation of fibers.
 - Composites with preferred orientation of fibers
2. Long-fiber reinforced composites. Long-fiber reinforced composites consist of a matrix reinforced by a dispersed phase in form of continuous fibers.
 - Unidirectional orientation of fibers.
 - Bidirectional orientation of fibers (woven).

APPLICATIONS

Fiber-reinforced plastics are best suited for any design program that demands weight savings, precision engineering, finite tolerances, and the simplification of parts in both production and operation.

A molded polymer artifact is cheaper, faster, and easier to manufacture than cast aluminum or steel artifact, and maintains similar and sometimes better tolerances and material strengths. The Mitsubishi Lancer Evolution IV also used FRP for its spoiler material.

Material	Specific gravity	Tensile strength (MPa)	Compressive strength (MPa)
Polyester resin (unreinforced)	1.28	55	140
Polyester and Chopped Strand Mat Laminate 30% E-glass	1.4	100	150
Polyester and Woven Roving's Laminate 45% E-glass	1.6	250	150
Polyester and Satin Weave Cloth Laminate 55% E-glass	1.7	300	250
Polyester and Continuous Roving's Laminate 70% E-glass	1.9	800	350
E-Glass Epoxy composite	1.99	1,770 (257 ksi)	N/A
S-Glass Epoxy composite	1.95	2,358(342 ksa)	N/A

ADVANTAGES AND LIMITATIONS OF COMPOSITES

FRP allows the alignment of the glass fibers of thermoplastics to suit specific design programs. Specifying the orientation of reinforcing fibers can increase the strength and resistance to deformation of the polymer. Glass reinforced polymers are strongest and most resistive to deforming forces when the polymers fibers are parallel to the force being exerted, and are weakest when the fibers are perpendicular. Thus this ability is at once both an advantage and a limitation depending on the context of use.

EXPERIMENTAL WORK PROCEDURES

MATERIAL SELECTION

Epoxy resin of dovecot 520F and Hardener of HY758 was used as matrix material which has the following advantages. Epoxies have better strength and stiffness properties over polyesters. Flexibility and improved performance is also achieved by the utilization of additives and fillers. Fiber cloth of oven bake glass fiber of 250 GSM was used as reinforcement material which has the following advantages. Less expensive of all the reinforcement. Glass fibers have high tensile strength to weight ratio. Glass fiber will not shrink or stretch during curing.

Composite Material Fabrication

Different ratios to be made with Hand lay-up process Ratio 90:10, 80:20, 70:30

GFRP composite was fabricated using hand lay-up technique. The procedures are as follow.

The matrix and fiber volume weight percentage of 50:50 ranges was taken for specimen preparation.

The fiber cloth was cut into 150mmx150mm square sheet and weighted in digital weighting machine. The epoxy resin and hardener were taken in 90:10 80:20, 70:30 percentage of 3 different specimen weights and thoroughly mixed. The releasing agent polyvinyl alcohol was applied on the stencil sheet which forms thin layer. Then small layer of resin mix was applied on the stencil sheet and first layer of fiber cloth was laid and hand roller was pressed over fiber for removal of air gap Additional layers of glass fiber cloths were added to build up desired thickness of 5mm. The resin hardens during curing, as the result of hardener that was added to the resin just prior to its use. The composite was allowed for curing at room temperature for minimum of two hours with applied compressive load.



Fig-1. Fabricated specimen (90:10)

EXPERIMENTAL PROCEDURE FOR DROP IMPACT TEST FOR CREATION OF ARTIFICIAL IMPACT DAMAGE

Drop impact test was carried out on Glass Fiber-Reinforced Polymer (GFRP) composite materials with different impact energy. The impact energy was varied by changing the height of impact and mass of impactor. The details of impactor settings are shown in table-1.

Table-1. The details of Impactor settings

Sl.No	Impact Energy J	Height of Impact test M	Mass of impact Kg
1.	15	0.85	1.76
2.	25	1.14	2.18
3	35	1.4	2.5
4.	40	1.58	2.52
5.	50	1.68	2.98

Impact damage was introduced on the composite plates using drop impact apparatus. The quality of fabricated composite materials was inspected through

visual and ultrasonic inspection. These tests confirm the uniform and defect free nature of the composite material. The experimental procedure is as follows. Composite specimen was fixed on the impact test apparatus. The load for drop weight selected from Table 1 and drop hammer moved for particular distance to impart certain impact energy on test specimen.

Then the load dropped freely to slide over guide wire. After the drop hammer hit the test specimen, drop hammer stopped to eliminate repeated impact. The tested specimens were shown in Fig 3.5 for different impact energy.

Table-2. Area of damage measured for different impact test

S.No	Impact Energy	Area of damage(mm ²)
1.	15	132
2.	25	236
3.	35	294
4.	40	363
5.	50	684

The damage area of impact tested specimen were analyzed and measured by using back illumination method for various energy of impact test. It is inferred that, as the area of impact damage induced on composite material increased with impact energy.



Fig-2.the tested specimens for impact

ANALYSES OF IMPACT DAMAGE

The damaged composite specimen with high impact energy has more damage area. From visual examination the composite specimen were damaged catastrophically at 50J impact energy. The strength for damaged were tested.

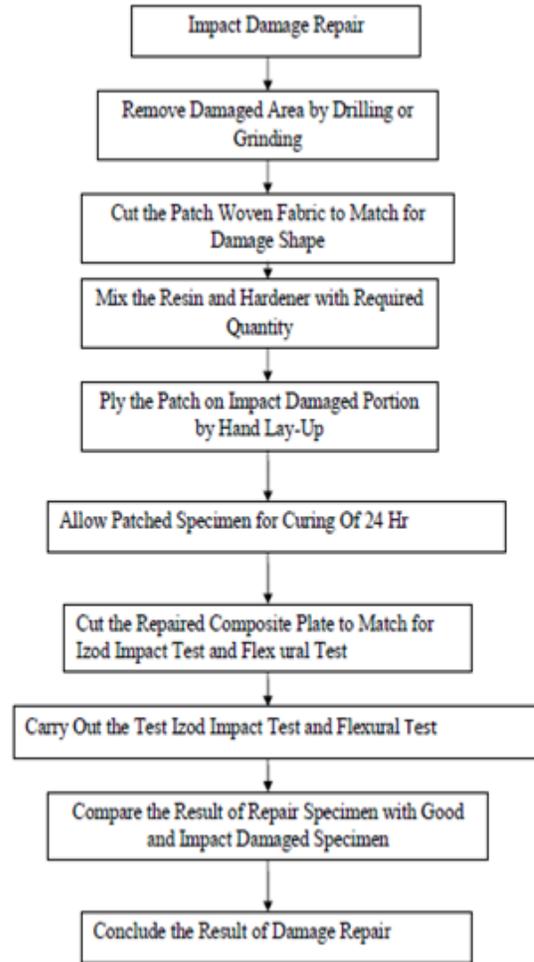


Fig-3.Flow chart for repair

REPAIR EXPERIMENTAL WORK

The experimental steps followed in characterization of damage repair are given in Fig.3 as flow chart. The area and criticality of damage on impact tested specimen were analyzed were shown in Fig.4. The specimen tested with 50J of impact energy was damaged drastically so, that specimen was taken firstly for repaired. The specimen was damaged full thickness of composite, so damage area was removed by drilling and abrasion using different file to oval shape as in Fig.4. The patch of woven fabric was cut to match for damage shape of oval as shown in Fig 5.The resin and hardener with required quantity were

mixed with 90:10 of weight ratio. The woven glass fabric laid on the impact damaged portion by hand lay-up. After laying all the patch fabric with subsequent resin application the repaired specimen allowed for curing of 24 hr. The impact damage repaired specimen was cut to dimension for Izod impact test and flexural test carry out the test Izod impact test and flexural test. The test procedure and precautions to be followed discussed in following section. Comparison of the result of repaired specimen with good and impact damaged specimen were carried out to check the suitability of composite repair



Fig-4. Damage area was removed by drilling

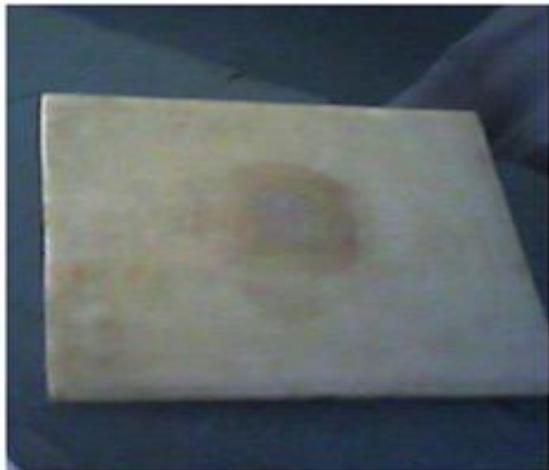


Fig-5. Rework finished material

TESTING PROCEDURE

SCANNED ELECTRON MICROSCOPE:

The scanning electron microscope uses a focused electron beam which is scanned on the surface of the sample to produce high quality images of the surface

topography. SEM essentially offers a very high magnification with very high resolution capabilities and a large depth of focus. This characteristic makes it an indispensable tool for analysis of a wide class of conducting, semi-conducting and insulating materials. A strong beam of electrons called primary electron beam is produced by thermionic emission using either tungsten or a Lanthanum Hexaboride (LaB6) filament. LaB6 filaments are preferred because of their long life and reasonable stability of electron beam emission. Lanthanum hex boride (LaB6) filaments have high thermionic emission characteristics and sufficiently low vapor pressures to be desirable cathode materials for electron microscopy. LaB6 cathodes provide around an order of magnitude higher brightness than tungsten cathodes. The primary beam of electrons thus emitted by thermionic emission interacts with the top atomic layers of surface of the sample.

This gives out a variety of signals that can be collected and processed to derive a good quality of information about the morphology of the sample, atomic contrast in the sample and the elemental composition of the top surface of the material. The different Possible interactions of the sample with a high energy electron beam are Primary electrons generate very low energy electrons called secondary Electrons from the top atomic layers of the sample that are used to analyze Its topographic nature. Primary electrons that are backscattered during interaction with sample Surface produce images with a high degree of atomic number contrast. Primary beam of electrons can ionize atoms of the sample that stabilize by Shell-to-shell transitions of electrons, which causes either emission of X-rays or Auger electron. The X-rays so emitted are characteristic of the elements

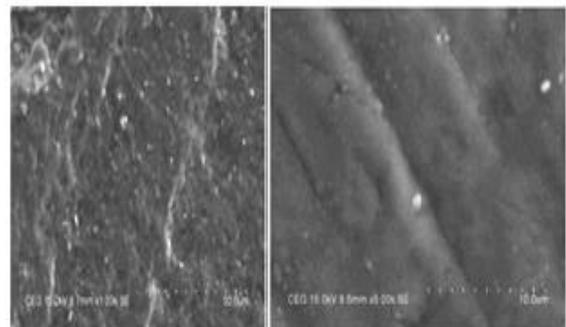


Fig-6. Scanning Electron Micrograph of Good Composite Material

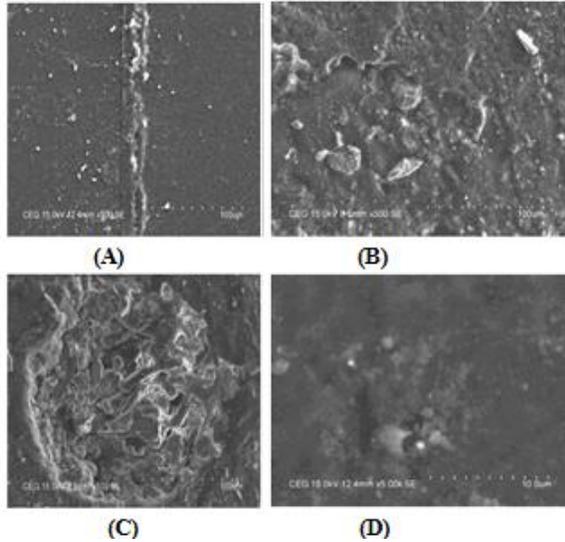


Fig-7. Scanning Electron Micrograph of Rework Composite Material

CONCLUSION

Composites are widely used in many industries such as automobile, aeronautical, Sports industry, civil engineering. The drop impact loads critical for aircraft composite components and damaged also produce unlimited defects or failure in the composites. Due to drop impact damage the composite strength decreases drastically this will affects the load carrying capacity and the performance of the material. The finding the damage will not reduce the problem of failures but rectification and repairing may help saving the composite material and saving the lives using the composite material. Here and attempt is carried out to repair the impact damaged composite specimen and increasing strength of damaged composite. The repaired composite experimentally tested for the suitability for further use, and then Impact damage was introduced on the composite plates using drop impact apparatus. The general procedure of repair were evaluation of damage, removal of damage, condition the surface of repair, cutting patches, lay-up of repair patches, curing, assessment of repair, The scanning electron microscope to be use analysis the three different type material one is good specimen, impact specimen, Rework specimen. To compare the both three material result is the rework material is better the more than two materials because no crack and damage will not show the scanning

electron microscope photo graph for rework material. So rework material can be re-used and reduces the wastage of class fiber reinforce composite material.

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