AL- Taqani , Vol. 27 , No. 4 , 2014

THE IMPACT PROPERTIES OF HYBRID COMPOSITE MATERIALS (GLASS CARBON/POLYESTER) +

Basim A. Sadkhan * **Jafar G. Majeed** *

Abstract :

This work focuses on the preparation of hybrid polymer matrix composite materials by (Hand Lay-Up) method, where the composite material was prepared from the unsaturated polyester resin (UP) as a matrix reinforced by bidirectional woven glass fiber kind (E-glass) with weight fraction of (10%+ 20%+30%) as first group of samples and the second group of samples reinforced with bidirectional woven fiber carbon kind (90-0) with weight fraction of (10%+20%+30%) instead of glass fiber. and the third group of samples reinforced with fiber glass and fiber carbon and polyester of ingredient hybrid. The values of Impact Strength increased with the increases of weight fraction of carbon and glass particles for both types of fibers that used in reinforced; and also results show that impact strength, Bending elastic modulus, Fracture Toughness increase with the increasing of carbon and glass particle size.

خواص الصدمة المفاجئة للمواد المركبة المهجنة من الايبوكسي الزجاجي المكربن

باسم عاجل سرحان **جعفر غني مجيد**

المستخلص :

يركز هذا العمل على إعداد مواد متراكبة هجينيه ذات اس بوليمري بطريقة الختط اليدوي ، حيث تم اعداد المواد المركبة من راتنجات البولستر غير المشبعة ( ) كماده اساس مقواة بالياف الزجاج المنسوجة من الثنائيه الاتجاه نوع E-GLASS مع جزء من الوزن (10%+20%+30%) والمجموعة الاولى من العينات والمجموعة الثانية من العينات عززت مع ثنائيالاتجاه المنسوجة من الياف الكاربون نوع (90-0) مع جزء من الوزن (10%+20%+30%) بدلا من الالياف الزجاجية. والمجموعة الثالثة من عينات عززت مع الالياف الزجاجية والياف الكاربون والبولستر من الهجين المكون.المقوى. وايضا اظهرت النتائج ان(اجهاد الصدمة ,معامل مرونة الانحناء,صلابة الكسر) تزداد بزيادة نسبة الكاربون وحجم الجسيمات للزجاج .

+ Received on 13/10/2013 , Accepted on 8/7/2014

* Lecturer / Engineering College / Al- Mustansirya University

1- Introduction to Composite Materials :

The concept of composite materials is ancient: to combine different materials to produce a new material with performance unattainable by the individual constituents. An example is adding straw to mud for building stronger mud walls. Some more recent examples, but before engineered materials became prominent, are carbon black in rubber, steel rods in concrete, cement/asphalt mixed with sand, fiberglass in resin etc. In nature, examples abound: a coconut palm leaf, cellulose fibers in a lignin matrix (wood), collagen fibers in an apatite matrix (bone) etc.

2- Classification of Composite Materials :

The reinforcement system in a composite material strongly determines the strengthening mechanism in a composite. It is thus convenient to classify composites according to the characteristics of the reinforcement, such as length, orientation etc.

3- Components of Composite Materials :

a. **Bulk phase:** matrix materials Polymers, Metals and Ceramics.
b. **Reinforcement:** fibers and particulate Glass, Carbon, Organic , Boron, Ceramic, Metallic and Interface

4- Fibers :

Reinforcements are not necessarily in the form of long fibers. They can be particles, whiskers, discontinuous fibers, sheets etc. A great majority of materials is stronger and stiffer in the fibrous form than in any other form. This explains the emphasis on using fibers in composite materials design[1]. There are many naturally occurring fibers: cotton, flax, jute, hemp, ramie, wood, straw, hair, wool, silk etc., but these have varying properties, and present many processing challenges. Fibers used in advanced composites have very high strength and stiffness but low density. They also should be very flexible (to allow a variety of methods for processing) and have high aspect ratio (length/diameter), that allows a large fraction of the applied to be transferred via the matrix to the fiber.

5- Types of Fibers :

Organic and inorganic fibers are used to reinforce composite materials. Almost all organic fibers have low density, flexibility, and elasticity. Inorganic fibers are of high modulus, high thermal stability and possess greater rigidity than organic fibers and not withstanding (can not resist) the diverse advantages of organic fibers which render the composites in which they are used. Mainly, the following different types of fibers namely, glass fibers, silicon carbide fibers, high silica and quartz fibers, aluminum fibers, metal fibers and wires, graphite fibers, boron fibers, agamid fibers and multiphase fibers are used. Among the glass fibers, it is again classified into E-glass, A-glass, R-glass etc. There is a greater marker and higher degree of commercial movement of organic fibers. The potential of fibers of graphite, silica carbide and boron are also exercising the scientific mind due to their applications in advanced composites.

6- Hybrid fabrics :

When two different fibers are weaved together hybrid fabric is formed. It may be combination of Carbon-Armed, Armed –glass, Carbon – glass, Carbon –metal, Armed –metal. Most commonly used Hybrid fabric is Carbon Armed. When desired properties of the end products could not be met by using single fibers, hybrid is designer's option. Designers specifies different weave structures and percentages if both carbon and agamid in a weave structure. Low impact resistance, brittleness and abrasion resistance of carbon fabrics are compensated by good impact strength of armed fibers. Consequently low compression strength of armed fibers is balanced by Good compression strength of carbon fabrics.
Such as Marine for speed boats, Personal protection in helmets and extra..
Woven Hybrid fiber Fabrics are used where strength and stiffness are important along with good impact and fatigue resistance. Hybrid fabrics show no thermal expansion. Hybrid fabrics are used as reinforcements in high performance composites which require high strength in tension and compression with stiffness and impact resistance.

7- Fiber Reinforcement :

Fibers are the important class of reinforcements, as they satisfy the desired conditions and transfer strength to the matrix constituent influencing and enhancing their properties as desired. Glass fibers are the earliest known fibers used to reinforce materials. and fibers were subsequently found out and put to extensive use, to render composites stiffer more resistant to heat. [2] Unidirectional loading is found in few structures and hence it is prudent to give a mix of orientations for fibers in composites particularly where the load is expected to be the heaviest. Monolayer tapes consisting of continuous or discontinuous fibers can be oriented unidirectional stacked into plies containing layers of filaments also oriented in the same direction. More complicated orientations are possible too and nowadays, computers are used to make projections of such variations to suit specific needs. In short, in planar composites, strength can be changed from unidirectional fiber oriented composites that result in composites with nearly isotropic properties. [3] .Properties of angle-plied composites which are not quasi-isotropic may vary with the number of plies and their orientations. Composite variables in such composites are assumed to have a constant ratio and the matrices are considered relatively weaker than the fibers. The strength of the fiber in any one of the three axes would, therefore be 1:3 of the unidirectional fiber composite, assuming that the volume percentage is equal in all three axes. There are several methods of random fiber orientations, which in a two-dimensional one, yield composites with 1:3 of the strength of an unidirectional fiber-stressed composite, in the direction of fibers. In a 3-dimension, it would result in a composite with a comparable ratio, about less than one-fifth. In very strong matrices, module and strengths have not been observed. Application of the strength of the composites with such matrices and several orientations is also possible. The longitudinal strength can be calculated on the basis of the assumption that fibers have been reduced to their effective strength on approximation value in composites with strong matrices and non-longitudinally orientated fibers. [4]

8- Laminar Composites :

Laminar composites are found in as many combinations as the number of materials. They can be described as materials comprising of layers of materials bonded together. These may be of several layers of two or more occurring alternately or fiber glass in a determined order more than once, and in as many numbers as required for a specific purpose. Sheets and foils can be made in two dimensions more easily than fibers. Foils and sheets are also made to exhibit high percentages of which they are put. For instance, a strong sheet may use over 92% in laminar structure, while it is difficult to make fibers of such compositions. Fiber laminates cannot over 75% strong fibers glass [5].

Designing hybrid composites :

Although hybrid fiber reinforced polymer composites are gaining interest, the challenge is to replace conventional glass reinforced plastics with bio composites that exhibit structural and functional stability during storage and use and yet are susceptible to environmental degradation upon disposal. An interesting approach in fabricating bio composites of superior and desired properties include efficient and cost effective chemical modification of fiber, judicious selection if fibers, matrix modification by functionalizing and blending and efficient processing techniques FIGURE (1-1) **.** Another interesting concept is that of "engineered natural fibers" to obtain superior strength bio composites .This concept explores the suitable blending of past (stem) and leaf fibers. The judicious selection of blends of bio fibers is based on the fact that the correct blend achieves optimum balance in mechanical properties for e.g., the combination of past and leaf fiber is expected to provide a stiffness toughness balance in the resulting bio composites. [4]

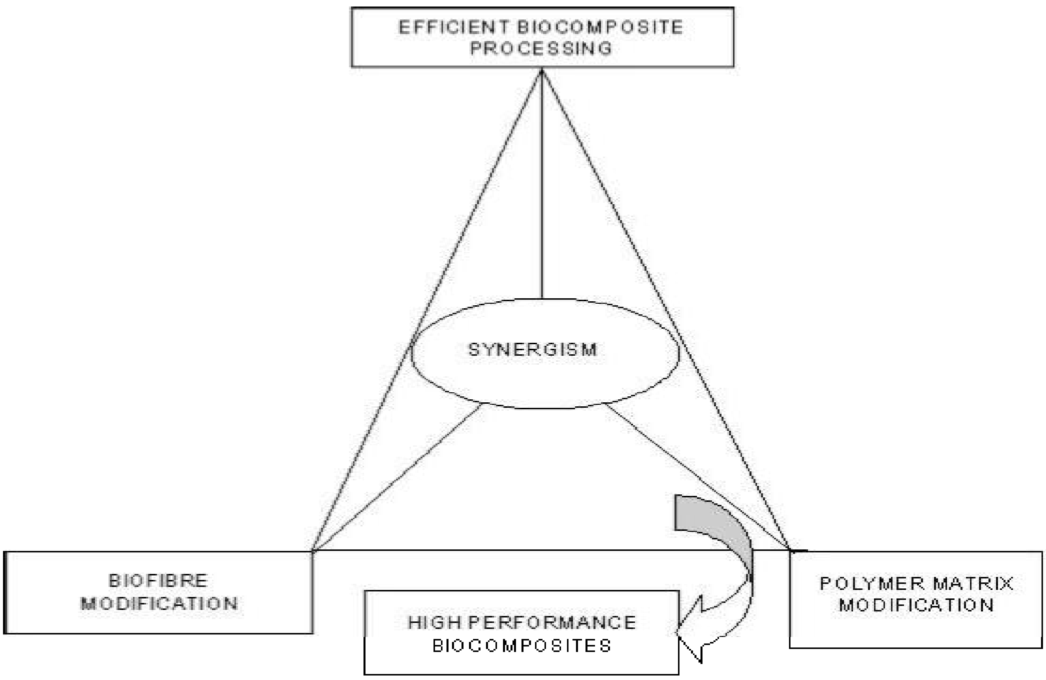


Figure (1): Tricorner approach in designing of high performance bio composites.

Theoretical and Experimental :

IZOD impact strength test : IZOD impact strength testing is an ASTM standard method of determining impact strength. A notched sample is generally used to determine impact strength. The test is named after the English engineer Edwin Gilbert IZOD (1876–1946), who described it in his 1903 address to the British Association, subsequently published in Engineering.[6] Impact is a very important phenomenon in governing the life of a structure. For example, in the case of an aircraft, impact can take place by a bird hitting a plane while it is cruising, or during takeoff and landing the aircraft may be struck by debris present on the runway, and as well as other causes. [7] An arm held at a specific height (constant potential energy) is released. The arm hits the sample and breaks it. From the energy absorbed by the sample, its impact strength is determined.
The dimensions of a standard specimen for ASTM D256 are 63.5 x 12.7 x 3.2 mm (2.5" x 0.5" x 1/8"). The most common specimen thickness is 3.2 mm (0.125"), but the width can vary between 3.0 and 12.7 mm (0.118" and 0.500"). [8]

The Impact Energy :

The phenomenon which occurs during the impact, according to the various loads, is showed by Figure (2). The force – time diagram can be split in two phases: one, when the breakage begins and the second when the breakage is spreading. As the load increases during phase one, the elastic deformation energy is gathered in the bar, subsequently leading to a microscopic scale breakage. At the same time, yielding mechanisms at a microscopic level can occur (micro-buckling of the fiber on the compressed side, link breaking in the fiber – matrix interface, etc.) When the critical load is reached at the end of the first phase, the composite material bar may yield due to the traction or shear breakage, depending on the relative values of the inter-laminar traction or the shear resistance. Once reached this point, the spreading of the breakage may take place in a catastrophic way – as in the case of fragile materials (at high loads) or in a progressive way – by keeping on absorbing the energy (at low loads). The total impact energy *Et* – registered on the testing device or by an oscilloscope (on the energy – time variation diagram) during loading – consists of initiating energy and spreading energy. The fragile materials are defined by high values of the breakage initiation energy and by low values of the breakage spreading energy, while tough materials are defined by a low breakage initiation energy and by a high spreading energy. Giving the fact that after summarization fragile and tough materials may have total impact energies comparable as size, knowing the total energy is not enough for explaining material behavior during breaking. In order to establish the energy absorbed (E) by the bar, based on impact experimental data, the following formula is often used [9]:

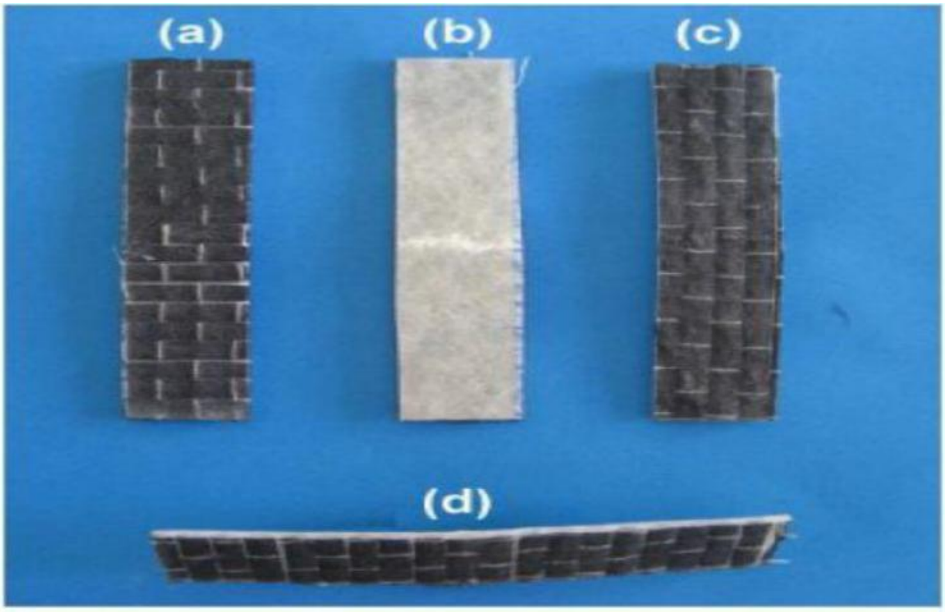


Figure (2): hybrid laminates- glass &carbon

$E = Ea(1- Ea/4E0)$ ……………………………………………………………......1

where *Ea* is the energy registered by the oscilloscope on the energy – time diagram and Eo is defined by the following formula:

$Eo = 1\backslash 2mv^2/$, …………………………………………………………………..2

where **Eo** is the initial impact rate.

The Impact Behavior of hybrid Materials :

Compared to traditional materials (steel and its alloys), hybrid materials have unique advantages of stating: high strength and stiffness - including the request variables and shock, good resistance to the environment (temperatures, rain, UV, humidity, temperature variations, etc.) and good mechanical stability, low density, and insulating properties and high fire, high resistance to wear and corrosion. [10]

3.1 Qualitative results

The qualitative results of the impact test can be used to determine the ductility of a material [10]. If the material breaks on a flat plane, the fracture was brittle, and if the material breaks with jagged edges or shear lips, then the fracture was ductile. Usually a material does not break in just one way or the other, and thus comparing the jagged to flat surface areas of the fracture will give an estimate of the percentage of ductile and brittle fracture. [11]

3.2 Sample sizes

According to ASTM A370,[11] the standard specimen size for CHARPY impact testing is 10mm×10mm×55mm. Sub size specimen sizes are: 10mm×7.5mm×55mm, 10mm×6.7mm×55mm, 10mm×5mm×55mm, 10mm×3.3mm×55mm, 10mm×2.5mm×55mm. Details of specimens as ASTM A370 (Standard Test Method and Definitions for Mechanical Testing of Steel Products). According to EN 10045-1, standard specimen sizes are 10mmx10mmx55mm. Sub size specimens are: 10mmx7.5mmx55mm and 10mmx5mmx55mm. According to ISO 148, standard specimen sizes are 10mmx10mmx55mm. Sup size specimens are: 10mmx7.5mmx55mm, 10mmx5mmx55mm and 10mmx2.5mmx55mm. [12]

Experimental work :

In this work the materials used in preparing the mould and the specimens are described, and the usage of impact apparatus are shown. Then the method used to determine the fracture load in this test is explained. Number of the samples in this test is **9** and their method of preparation according to testing requirements is presented. Glass and carbon fibers are used to reinforce the composite materials.

Chart (1): shows the work steps from sample preparation process until samples impact operation is completed.

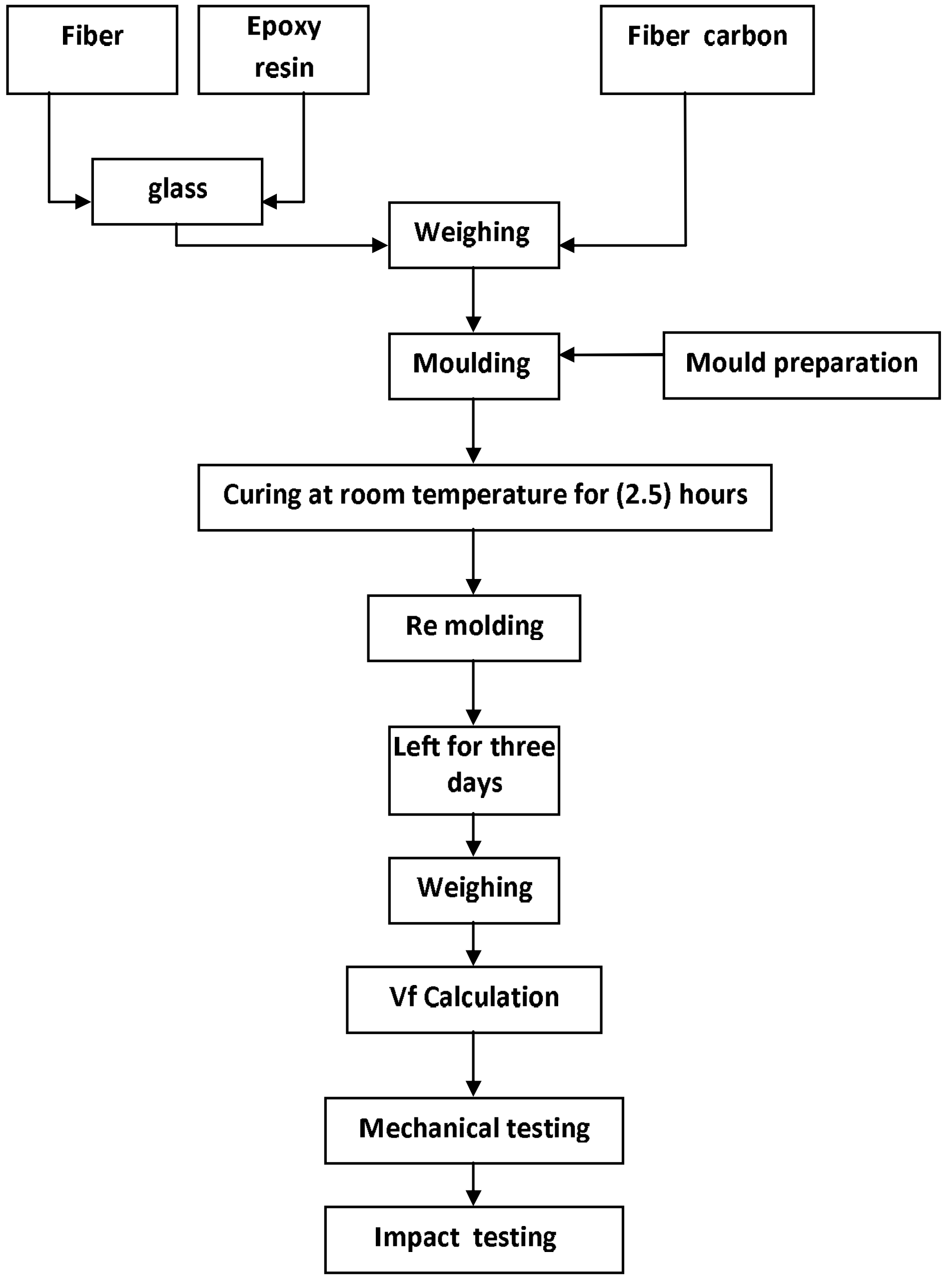


Chart (1) work from sample preparation process until samples Impact testing performed

The properties of carbon fibers, such as high stiffness, high tensile strength, low weight, high chemical resistance, high temperature tolerance and low thermal expansion, make them very popular in aerospace, civil engineering, military, and motorsports, along with other competition sports. However, they are relatively expensive when compared to similar fibers, such as glass fibers or plastic fibers.

Carbon fibers are usually combined with other materials to form a composite. When combined with a plastic resin and wound or molded it forms carbon fiber reinforced plastic (often referred to as carbon fiber) which has a very high strength-to-weight ratio, and is extremely rigid although somewhat brittle. However, carbon fibers are also composed with other materials, such as with graphite to form carbon-carbon composites, which have a very high heat tolerance. [13]

The most common reinforcement for the polymer matrix composites is a glass fiber. Most of the fibers are based on silica (SiO2), with addition of oxides of Ca, B, Na, Fe, and Al. Of the all fibers, the E-glass is the most common reinforcement material used in civil structures.

It is produced from lime-alumina borosilicate which can be easily obtained from abundance of raw materials like sand. The glass fiber strength and modulus can degrade with increasing temperature. Although material creeps under a sustained load, it can be designed to perform satisfactorily. The fiber itself is regarded as an isotropic material and has a lower thermal expansion coefficient than that of steel.

Epoxy resin is a thermosetting resin, with relatively good mechanical properties, as shown in table (1). Also this resin is characterized by good toughness, low shrinking degree, good resistance to chemical attack and weather circumstances, and good adhesion with various fibers, in comparison with other types of thermosetting [4].

Table (1): the set typical properties for polyester resin

Density gm / cm^3	Thermal conductivity w/m.c^o	Specific Heat J/ kg. k	Coefficient of thermal expansion $10^{-6}(c^o)^{-1}$	Fracture Toughness MPa-$m^{0.5}$	Tensile strength MPa	Percent Elongation (EL%)	Modulus of elasticity Gpa
1.2	0.17	710-920	100-180	0.6	41.4-89.7	< 2.6	2.06-4.41

Why Carbon Fabric is used ? Very high tensile strength, Very high tensile modulus, High compressive strength, High compressive modulus, High flexural strength, High flexural modulus, High inter laminar shear strength, High in plane shear strength, High fatigue resistance, Low thermal expansion.

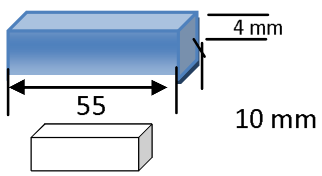
Fabrication of composite :

The glass fibers and carbon fiber were cut to standard size rectangular sheets (long 36 mm width 20mm) The plies were then weighed and amount polyester resin and hardener. Care was taken to avoid entrapment of air bubbles. Because the air bubbles trapped in the matrix will result in void formations, which result in concentration of stress and thereby resulting in crack formation. A plastic die with dimensions (long 36mm width5 mm) is used, on to which mold release spray was sprayed, then a polyester was coated on the sheet, now alternately, layers of carbon fiber fabric and glass fiber fabric were laid upon other, with a layer of resin in between such fabric. [4] The stacking sequence was maintained. At last a layer of resin mix was applied to it and this was put on to the last layer of composite. A flat board was then put on these sheets and dead loads were applied on prepared composite above this board, and the whole was then allowed to cure for around 3 hours. Nine test dies used to produce one molds with different fiber layers arrangement, produce three groups of specimens molded in each group there is three specimens as shown in table (2) bellow.

Table (2): (weight fraction of carbon and glass)

	Weight fraction of glass	weight fraction of carbon	weight fraction of carbon / Glass
Group (A)	10%	10%	10% + 10%
Group (B)	20%	20%	10% + 20%
Group (C)	30%	30%	10% + 30%

The standard specimen of ASTM is (55 X 10 X 4 mm) (0.144 X 0.022 X 0.016 inch) the common specimen thickness is 4 mm, but preferred 5 mm thickness because it is not as likely to bend or crush



Test Procedure& Impact Testing Devices :

The specimen is clamped into the pendulum impact test fixture with the thin edge facing the striking edge of the pendulum. The pendulum is released and allowed to strike through the specimen. If breakage does not occur, a heavier hammer is used [12].

Unlike metals, fiber reinforced hybrid materials don't undergo plastic deformations after the impact. Near the impact area may appear elastic deformations (in the case of a low intensity impact) or deteriorations of the material (the separation of the fibers from the matrix, matrix cracking, fiber breaking). The absorbed energy consequent to the impact depends, among others parameters, on the fiber – resins link resistance. If this link is strong, a continuous crack may spread along the material. In the case of a weak link, the generated crack may have an irregular form, leading to a rapid separation of the fibers from de matrix and to a considerable absorption energy. When designing the hybrid materials, it is necessary to make sure that the links between the fibers and the matrix aren't too weak, because a low shear resistance also influences in a negative way of the impact behavior. A simple analysis method of impact properties is the measurement of the stiffness expressed in the necessary energy for breaking a random geometry bar. [11]

Although the deterioration mechanisms (matrix crack, fiber separation or yield) may occur in an independent manner, the interaction of these factors and the fiber type, the matrix type/state and environment state and matrix – fiber links define the impact and the possible yielding of the material as a very complex phenomenon. There are many methods for identifying the performances of the hybrid materials on impact. Figures (3) and (4) show two devices. [3]

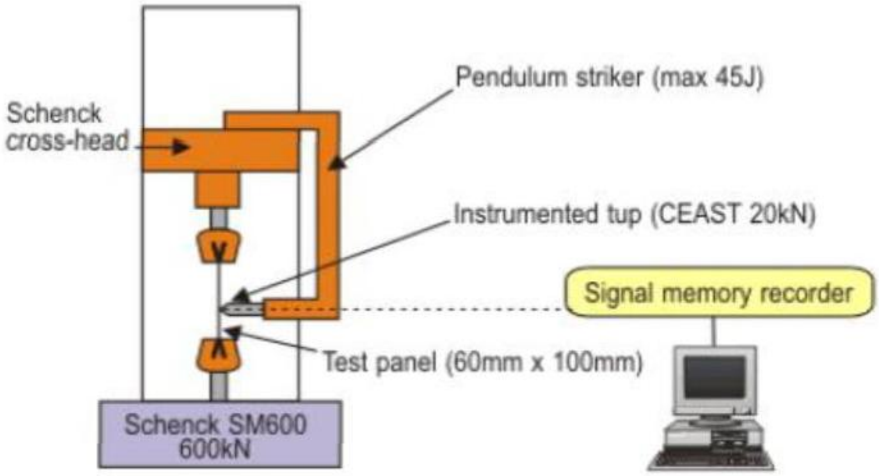


Figure (3): Low velocity impact device used for pre-stressed hybrid materials

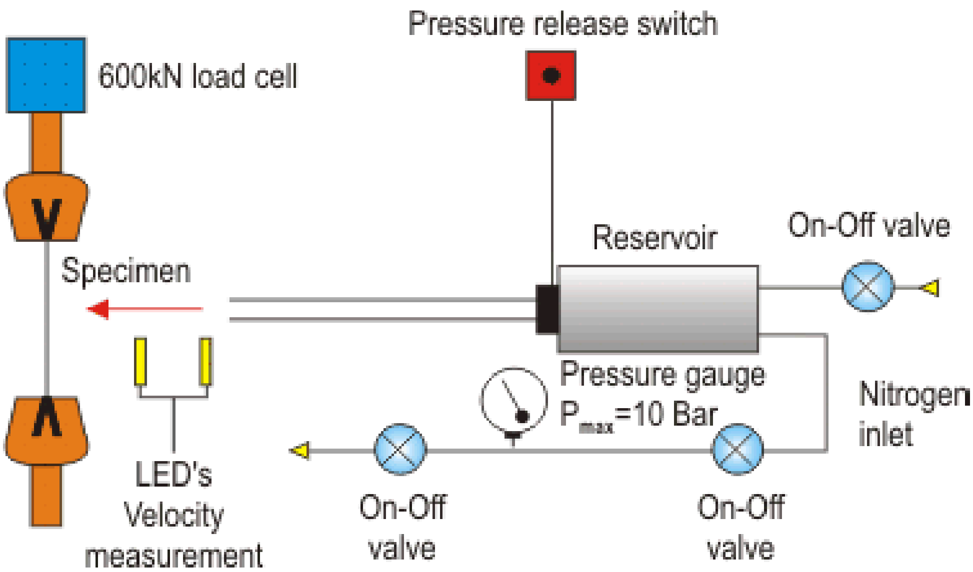


Figure (4): Blast gun for med of pre-stressed composite materials

A widely used test in the case of impact behavior study of composite plates is the drop weight test [14], where the bar placed on a rigid stand is hit by a body with known weight which falls down from a certain height. This height may vary in order to obtain de desired impact velocity. [15] An impact stress device for fiber reinforced multilayer composite materials figure (5), in accordance to the 04.26.383 IGC standard for testing the unidirectional or canvas fiber reinforced multilayer composite materials on low velocity impact. These tests can be run on various energy levels, thus obtaining: the delaminated surface area; the depth of the missile mark; the residual traction resistance after the impact.

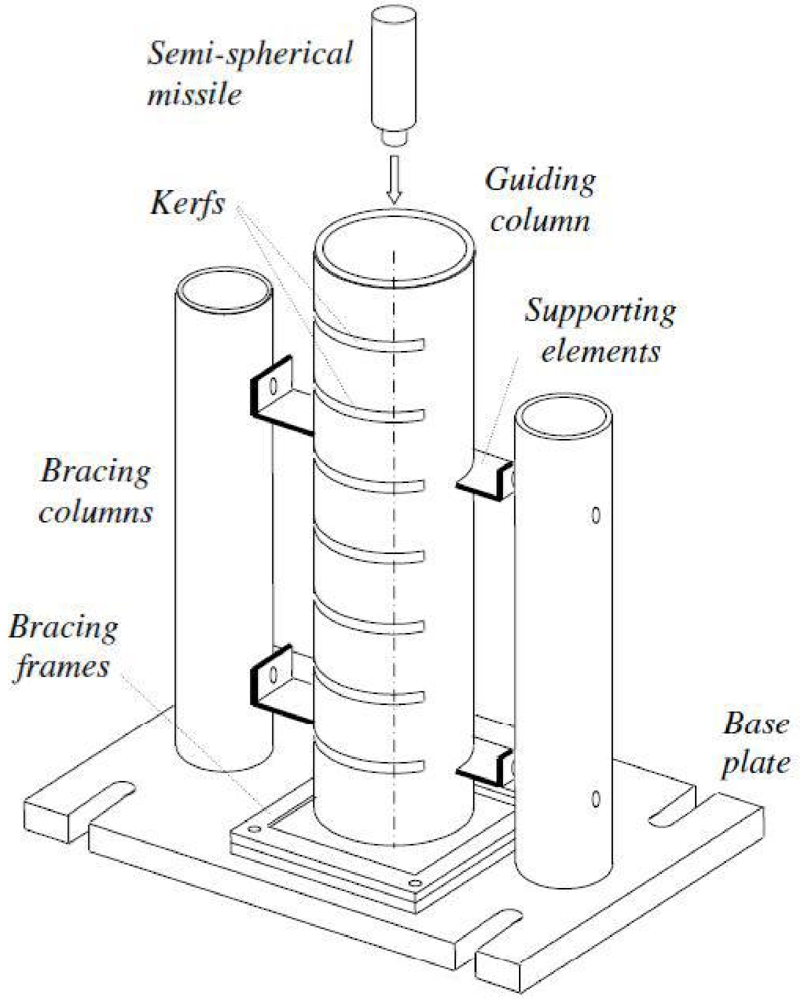


Figure (5): Impact stress device

The device has a compact structure consisting in a OL37 rectangular stand plate having the dimensions of 500 x 300 x 20 [mm]. The plate is provided with a window of 350 x 200 [mm] in dimensions. The bar – plate, with dimensions of 300 x 150 [mm] is provided with four holes of in the corners, which insure the grip on the base plate through a frame. [5] The impact is obtained using a missile with a mass varying from 3 to 6 kg, which is lead in a 1,65 m long cylindrical column. In order to obtain various energy levels, the leading column is provided with 10 equidistant holes for retaining the missile at different heights. When the retainer is removed, the missile slides and hits the bar which is stuck on the plate. The missile has the length of 195 mm and is made of a cylindrical body with a 50 mm diameter which continues with a semispherical area with the radius of 8 mm. The obtained energy levels vary from 5 to 95 J. In order to obtain lower energies (1…15 J), a smaller size missile could be used (1 kg mass and 10 mm semispherical radius). The device prevents the multiple impact.[16]

CHARPY impact test :

The CHARPY impact test, also known as the CHARPY V-notch test, is a standardized high strain-rate test which determines the amount of energy absorbed by a material during fracture. This absorbed energy is a measure of a given material's notch toughness and acts as a tool to study temperature-dependent ductile-brittle transition. It is widely applied in industry, since it is easy to prepare and conduct and results can be obtained quickly and cheaply. A disadvantage is that some results are only comparative
The test was developed around 1900 by S. B. Russell (1898, American) and G. CHARPY (1901, French).[2] The test became known as the CHARPY test in the early 1900s due to the technical contributions and standardization efforts by GEORGES CHARPY. The test was pivotal in understanding the fracture problems of ships during WWII
Today it is used in many industries for testing materials used in the construction of pressure vessels and bridges and to determine how storms will affect materials used in them. [17]
The energy transferred to the material can be inferred by comparing the difference in the height of the hammer before and after the fracture (energy absorbed by the fracture event).
The notch in the sample affects the results of the impact test, thus it is necessary for the notch to be of regular dimensions and geometry. The size of the sample can also affect results, since the dimensions determine whether or not the material is in plane strain. This difference can greatly affect conclusions made
The "Standard methods for Notched Bar Impact Testing of Metallic Materials" can be found in ASTM E23, ISO 148-1, or EN 10045-1, where all the aspects of the test and equipment used are . [9]

Results and Discussion :

The experimental results are discussed for the three groups . Group (A) sample (1) (glass fiber 10% + polyester 90%) weight fraction and sample (2) (glass fiber 20 % + polyester 80%) weight fraction and sample (3) (glass fiber 30 % + 70 % polyester) weight fraction . Group (B) sample (1) (carbon fiber 10% + polyester 90%) weight fraction and sample (2) (carbon fiber 20 % + polyester80%) weight fraction and sample (3) (carbon fiber 30 % + polyester 70%) weight fraction . Group (C) sample (1) (glass fiber 10% + carbon fiber 10% + polyester 80 %) weight fraction and sample (2) (glass fiber 10% + carbon fiber20% + polyester 70%) weight fraction and sample (3) (glass fiber 10% + carbon fiber30% + polyester 60%) weight fraction . All the results are made using one weight fraction ratio for each group.
The Impact test results outline in this paragraph are for hybrid composite material of reinforced polyester resin with different weight fraction for each group of specimens. And the Impact test specimens with dimension of and all tests are performed at laboratory temperature.
The figures (6,7 and 8) obtained from the Impact test machine are in the shape of a relationship between weight fraction (W_f) and the Impact strength (KJ/ m^2) . [7]
The specimen table (3),figure(6B) Group (A) the sample (1) (fiber glass 10% + 90% polyester) layers is fracture specimen load range applied (5.5) J and energy requisite for

sample fracture (U_c) (0.53)(J) and the Impact resistant of material (G_c) (0.64) (J/m^2) and the fracture durable for material (K_c)(0.44) $N/mm^{3/2}$ and area cross section (A) (0.55) m^2
The specimen table (3) ,figure(6B) Group (A) the sample (2) (fiber glass 20% + 80% polyester) layers is fracture specimen load range applied (5.5) J and energy requisite for sample fracture (U_c) (0.75)(J) and the Impact resistant of material (G_c) (1.34) (J/m^2) and the fracture durable for material (K_c)(0.634) $N/mm^{2/3}$ and area cross section (A) (0.55) m^2[13].
The specimen table (3) ,figure(6B) Group (A) the sample (3) (fiber glass 30% + polyester 70%) layers is fracture specimen load range applied (5.5) J and energy requisite for sample fracture (Uc) (1.25)(J) and the Impact resistant of material (G_c) (2.272) (J/m^2) and the fracture durable for material (K_c)(0.83) $N/mm^{3/2}$ and area cross section (A) (0.55) m^2
The specimen table (4) ,figure(7B) Group (B) the sample (1) (fiber carbon 10% + polyester 90%) layers is fracture specimen load range applied (5.5) J and energy requisite for sample fracture (U_c) (1.15)(J) and the Impact resistant of material (G_c) (2.1) (J/m^2) and the fracture durable for material (K_c)(0.79) $N/mm^{3/2}$ and area cross section (A) (0.55) m^2
The specimen table (4) ,figure(7B) Group (B) the sample (2) (fiber carbon 20% + polyester 80%) layers is fracture specimen load range applied (5.5) J and energy requisite for sample fracture (U_c) (1.2)(J) and the Impact resistant of material (G_c) (2.18) (J/m^2) and the fracture durable for material (Kc)(0.81) $N/mm^{3/2}$ and area cross section (A) (0.55) m^2
The specimen table (4) ,figure(7B) Group (B) the sample (3) (fiber carbon 30% + polyester 70%) layers is fracture specimen load range applied (5.5) J and energy requisite for sample fracture (U_c) (1.4)(J) and the Impact resistant of material (G_c) (2.55) (J/m^2) and the fracture durable for material (Kc)(0.88) $N/mm^{3/2}$ and area cross section (A) (0.55) m^2[3]
The specimen table (5) ,figure(8B) Group (c) the sample (1) (fiber carbon 10% + fiber glass 10% +polyester 80%) layers is fracture specimen load range applied (5.5) J and energy requisite for sample fracture (U_c) (1.75)(J) and the Impact resistant of material (G_c) (3.18) (J/m^2) and the fracture durable for material (Kc)(0.98) $N/mm^{2/3}$ and area cross section (A) (0.55) m^2 The specimen table (5) ,figure(8B) Group (c) the sample (2) (fiber carbon 20% + fiber glass 10% +polyester 70%) layers is fracture specimen load range applied (5.5) J and energy requisite for sample fracture (U_c) (3.5)(J) and the Impact resistant of material (G_c) (6.36)
(J/m^2) and the fracture durable for material (Kc)(1.38) $N/mm^{3/2}$ and area cross section (A) (0.55) m^2 The specimen table (5) ,figure(8B) Group (c) the sample (3) (fiber carbon 30% + fiber glass 10% +polyester 60%) layers is fracture specimen load range applied (5.5) J and energy requisite for sample fracture (U_c) (4.35)(J) and the Impact resistant of material (Gc) (7.9) (J/m^2) and the fracture durable for material (K_c)(1.54) $N/ mm^{3/2}$ and area cross section (A) (0.55) m^2.

Table (3): Group A (fiber Glass + polyester)

Specimen	U_c (J)	G_c (J/m^2)	K_c $N/mm^{3/2}$	weight fraction	E_b Mpa
No.1	0.35	0.64	0.44	10%	0.3
No.2	0.55	1.34	0.63	20%	0.3
No.3	0.75	2.27	0.83	30%	0.3

$$G_c = \frac{U_c}{A} \quad \ldots\ldots 1$$

$$K_c = \sqrt{G_c E_b}$$

Table (4): Group B (fiber carbon +polyester)

Specimen	U_c (J)	G_c (J/ m^2	K_c $N/mm^{3/2}$	V_f	E_b Mpa
No.1	1.15	2.1	0.79	10%	0.3
No.2	1.2	2.18	0.81	20%	0.3
No.3	1.4	2.55	0.88	30%	0.3

Table (5): Group C (fiber carbon + fiber Glass + polyester)

	U_c (J)	G_c (J/ m^2	K_c $N/mm^{3/2}$	W_f Glass	W_f Carbon	E_b mpa
No1	1.75	3.18	0.976	10%	10%	0.3
No1	3.5	6.36	1.38	10%	20%	0.3
No1	4.35	7.9	1.54	10%	30%	0.3

$$E_t = E_f\ V_f + E_m\ V_m \quad \ldots\ldots 2$$

Where …….

K_c : Fracture durability of material $N/mm^{3/2}$
U_c : energy crisis to fracture of sample (J)
G_c : Impact resistant of of material J/m^2
A : cross section of area (m^2)
E_b : modulus plasticity of polyester Mpa

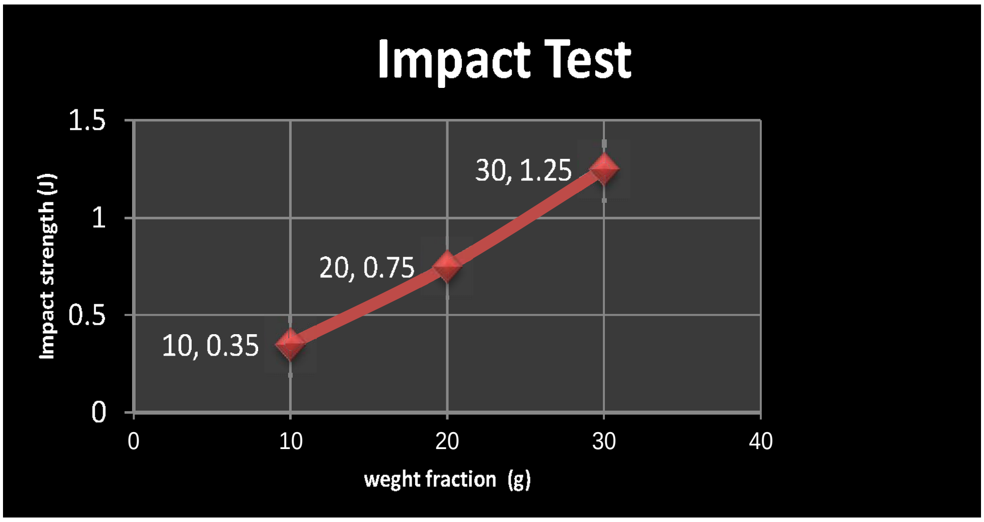


Figure (6A): impact strength &Wight fraction Group A

According to the above graph, it is easy noticed that there is a linear relation between the weight fraction and impact strength. At weight fraction 10%, the impact strength is approx. (0.35)gm and then increase in dramatic manner to reach to 1.25 at 30 % . This behavior attributed to the affect of reinforcement (fiber glass) layers which

Figure (6B): Group (A) (fiber Glass + polyester)

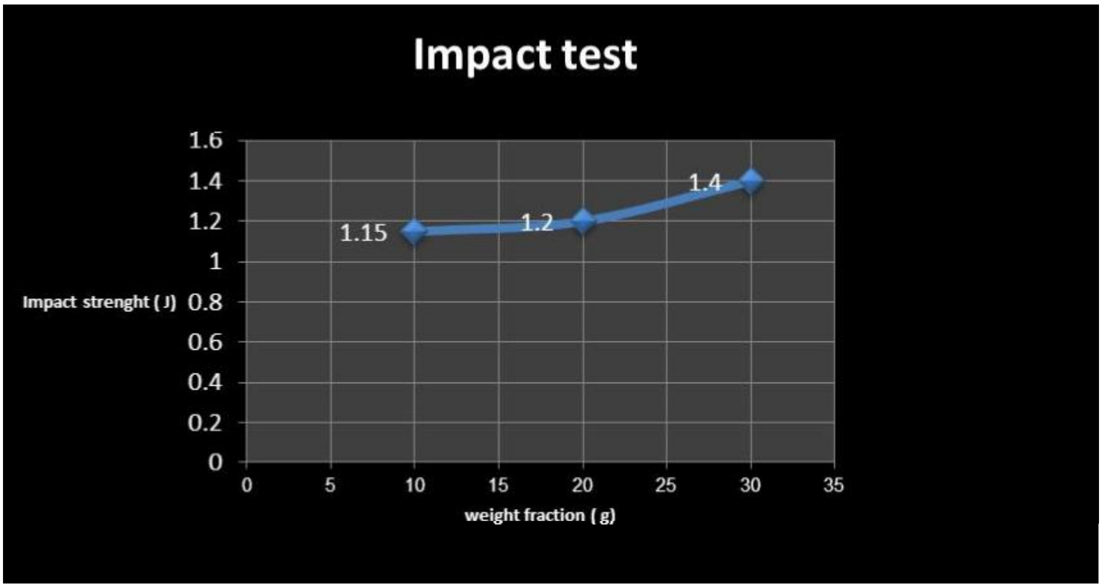


Figure (7A): impact strength &Wight fraction Group B

According to the above graph, it is easy noticed that there is a linear relation between the weight fraction and impact strength. In the Group (B) At weight fraction 10%, the impact strength is approx.(1.15) and then increase in dramatic manner to reach to(1.4) at 30 % . This behavior attributed to the affect of reinforcement (fiber Carbon) layers. Where Impact strength of fiber carbon increasing above the impact strength of fiber glass with shape lucid.

Figure (7B): Group (B) (fiber carbon +polyester)

According to the above graph, it is easy noticed that there is a linear relation between the weight fraction and impact strength. In the Group (C) At weight fraction 20%, the impact strength is approx.(1.75) and then increase in dramatic manner to reach to(4.35) at 40 % . This behavior attributed to the affect of reinforcement (fiber Carbon + fiber Glass) layers. Where Impact strength of hybrid increasing above the Impact strength of (fiber glass + polyester) or (fiber Carbon + polyester) with shape lucid.

Figure (8A): impact strength &Wight fraction Group C

Figure (8B): Group (C) (fiber Carbon + fiber Glass + polyester)

The figures(9 and10) represented comparison between two different systems ; (polyester and fiber glass) and (polyester , carbon fiber , and fiber glass) , and we noticed that the difference in impact strength at 20% percent reach and (30 %) reach to (1) and (1.7) respectively for figure (13) and (30 %) reach to (2.3) and (2.95) respectively for figure (14). In fact, this behavior attributed to the affect of carbon fiber which has mechanical properties when compared with fiber glass.

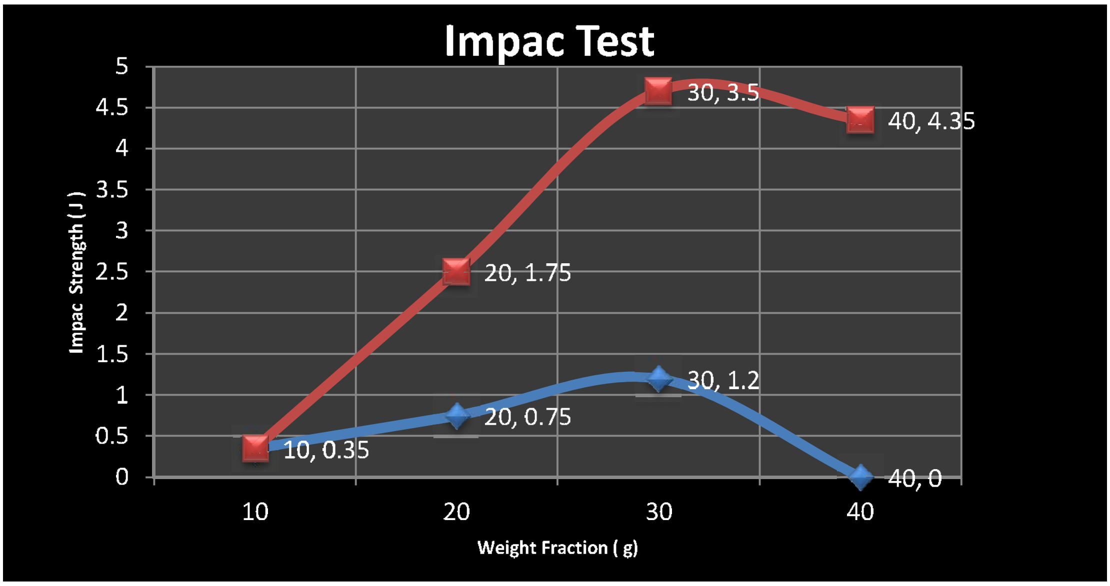


Figure (9): (Polyester And Fiber Glass + Hybrid)

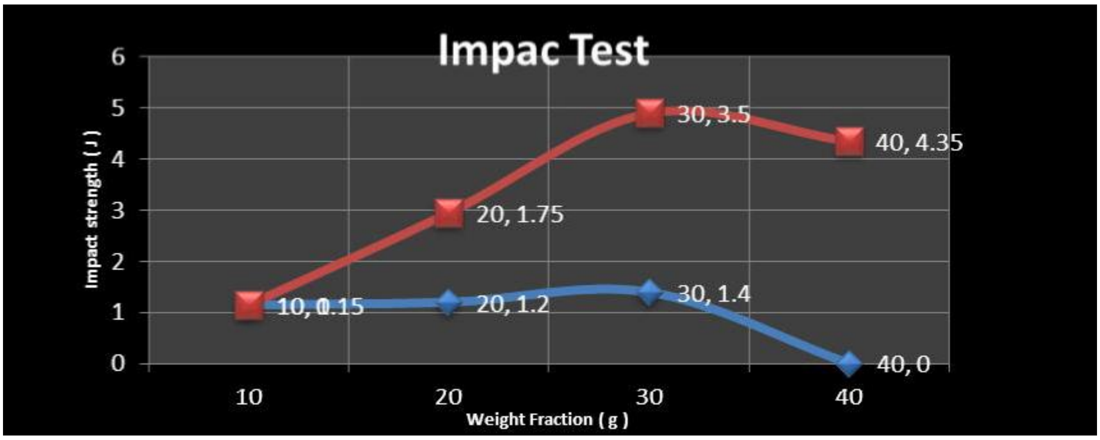


Figure (10): (Polyester And Fiber Carbon + Hybrid)

The Impact tests discussion outline in this paragraph are for hybrid composite materials. The Impact tests show when be carbon fiber layer more than glass fiber in specimen the fracture load and elongation will be high. Otherwise the difference in fracture load increased with increasing number of layers but the difference in elongation remained or not so difference. And the Impact properties become close to each other with increased number of layers see figure (11).

Figure (11): (Samples Form After Inspection)

References :

1. R. K. Jain , S. K. Goswang & K. K. Asthana ,*"Composite"*, , P.P, (69-72) Vol. 10, No. 1 (1979).
2. B. Z. Jang, *"Impact Resistance & Energy Absorption Mechanine in Hybrid Composites"*, Composite Science &Technology,. Elsvier Applied Science Co P.P 305 Vol. 34, No. 4, (1989).
3. *"Resistance to Brittle Fracture of Glass Reinforced Polymer Composites Used in Composite (Nonceramic) Insulation"*, Lucas, Maciej. S. Kumosa, Daniel. L. Armentrout, Journal of "IEEE TRANSACTIONS ON POWER DELIVERY", Vol. 20, No. 4, October, (2005).
4. N. G. Crum, C. P. Buckley & C. B. Bucknall, *"Principles of polymer Engineering"*, 2nd ed., John Wiley & Sons, New York, (1997).
5. 5 *"Mechanical Properties of Composites Based on Low Styrene Emission Polyester Resins for Marine Application"*, Christophe Baley, Y. Perrot, Peter Davies, Journal of Applied Composite Materials, Vol. 13, No. 1, January, (2006), P.P, (1-22).
6. Derek Hull, *"An Introduction to Composite Materials"*, Cambridge University Press, first Published, (1981).
7. K. S. Han & J. Koutsky,*"Composite"*, , P.P, (67-70), Vol. 14, No. 1, (1983).
8. Dr. Shridhar Yarlagadda, *"Introduction To Composites"*, University of Delaware Center for Composite Materials/ yarlagad @ Com.udel.edu, 302-831-4941, (2007).
9. L .Holliday, *" Composite Material "* Elsevier Publishing, London, (1966).
10. A.A. Berlin, S. A. Volfson,*"principles of polymer composites"*, springer – verlag,), P45 New York, (1986.
11. R. Mac Neil, *"Composites Manufacturing "*, January, 16-29, (2005).
12. *"Future Requirements in the characteristics of continuous fiber Reinforced polymeric composites*", the National Academy of science, www. nap. edu/ open book /03090956/htm1/20.htm 1, (2002).
13. B. Z. Jang, *"Impact Resistance & Energy Absorption Mechanics in Hybrid Composites"*, Composite Science &Technology, Elsvier Applied Science Co P.P 305. Vol. 34, No. 4, (1989).
14. Dod Coordination Draft, *"Polymer matrix Composite materials Properties"*, Department of Defense, washing D. C. (1996).
15. Edwin P. Plued deman, *"Interface in polymer matrix composites"*, Vol. 6, Academic press, (1974).
16. Daniel & Ishai, *"Engineering Mechanics of Composite Materials"*, ACMC University of Plymouth , (2006).
17. "*SP System Guide to Composite Engineering Materials"*, www. SP System. com. (2004),