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Studies on Tailoring of Structural Components using Hybrid composites for aerospace & critical applications

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Abstract - Polymer matrix composite (PMC) is the type of composite which has been selected for this study, due to its versatility of application. PMC is the type of composite with polymer materials acting as main constituent (matrix) and have another material or more in it. PMC have established themselves as engineering structural materials, not just as laboratory curiosities or cheap stuff for making chairs and tables. This came about not only because of introduction of high performance such Glass, carbon, boron and aramid but also some new and improved engineering materials. Glass, carbon and Kevlar fibers are extensively being used as reinforcement in the resin matrices like unsaturated polyesters, epoxies, phenol formaldehyde etc. The composites of these (i.e. with epoxy resin) glass epoxy, and carbon epoxy composites are most widely used material. Polymer composites offer several advantages over conventional materials like, higher fatigue strength, corrosion resistance, very high strength to the weight ratio, ease of fabrication, assembly, installation and maintenance etc. Further, they are very economical when manufactured using appropriate fabrication technique. As found out and established in the development and evaluation of hybrid composites the strength and impact properties can be optimized using the hybrid construction and so the purpose of designing the above types of components for aircraft can be tailored to have the minimum weight with the desired levels of impact and strength along with other desirable properties such as low water absorption etc by having the desirable layup sequence such as use of glass fabric on the top layers to avoid ingress of moisture . The core hover made up of Kevlar will tremendously improve the impact behaviour at a much lower weight.
Keywords - PMC, Kevlar, epoxy resin. Armid, fibre

I. INTRODUCTION

Composite materials are engineered materials with two or more material constituents having significant different physical and chemical property which remain separate at macroscopic level in the finished structure with their high stiffness, high strength, and low weight properties[1]. These are attractive materials for industries with advance needs such as aerospace, naval, weapons, automobile and machine tool industries; however the mechanical property of composite material may be severely degraded in the presence of defect. Furthermore the delaminating type of defect can render active damping ineffective. Since failure of structure often have catastrophic consequences, on line structure integrity monitoring and offline reliable inspection method are employed to ensure safety and reliability in many field of engineering, particularly in aerospace. A large number of effort and researches have been dedicated to developed new and better non destructive inspection (NDI) techniques, to predict the structural integrity of the composites in primary and secondary areas. These include visual, tap tests, ultrasonic scanning, acoustic emission, radiography etc [2].

II. LITERATURE REVIEW

Among the first uses of modern composite materials was about 30 years ago when boron-reinforced epoxy composite was used for the skins of the empennages of the U.S. F14 and F15 fighters. Initially, composite materials were used only in secondary structures, but as knowledge and development of the materials has improved, their use in primary structures such as wings and fuselages has increased. The following figure shows some aircrafts in which significant amounts of composite materials are used in the airframe. Initially, the percentage by structural weight of composites used in manufacturing was very small, at around two percent in the F15; however, the percentage has grown considerably, through 19 percent in the F18 up to 24 percent in the F22.The distribution of materials in the F18E/F aircraft. The AV-8B Harrier GR7 has composite wing sections and the GR7A features a composite rear fuselage. Composite materials are used extensively in the Euro fighter: the wing skins, forward fuselage, flaperons and rudder all make use of composites. Toughened epoxy skins constitute about 75 percent of the exterior area. In total, about 40 percent of the structural weight of the Euro fighter is carbon-fiber reinforced composite material. Other European fighters typically feature between about 20 and 25 percent composites by weight: 26 percent for Dassault's Rafael and 20 to 25 percent for the Saab Gripen and the EADS Mako. The B2 stealth bomber is an interesting case. The requirement for stealth means that radar-absorbing material must be added to the exterior of the aircraft with a concomitant weight penalty. Composite materials are therefore used in the primary structure to offset this penalty. The use of composite materials in commercial transport aircraft is attractive because reduced airframe weight enables better fuel economy and therefore lowers operating costs.

III. EXPERIMENTAL PROCEDURE

A. Casting preparation

This section deals with the detailed procedure of preparation of casting, method of preparation, and raw materials used.

1) Materials and process used

Resin : - DEGBA epoxy(LY-556).
Curing agent : - Diamonodiphenyl sulphone (DDS).
Casting method : - Open mould.
Curing temperature : - 180^o C.
Curing period : - 60-90 minute.
Mixing method : - Mechanical mixing with stirrer.

2) Blending of PEI solution with Epoxy: The DDS (36% weight percentage of epoxy taken) powder is mixed with epoxy resin (35% by weight of fabric). Mixing takes place with the help of mechanical stirrer, The DDS is mixed around 15-20 minute at regular interval with constant amount. As per the requirement when viscosity of resin increases, I mixed optimum amount of Ethyl Methyl Kenton as a solvent. It gets vaporized at room temperature and doesn't affect on the properties of composite. The heating rate is 1 ^{o}C/min is given to the epoxy resin and optimum amount of DDS (Diamonodiphenyl sulphone) is poured with respect to time so that ≈ at 100 ^{o}C whole amount of DDS is poured. At 120^o C the particle of DDS is mixed, clear solution is appearing then stop the stirrering and go for coating the layers of fiber.

3) Processing procedure: Simultaneously after the DDS is uniformly mixed with Epoxy- blends. It is poured in the open mould (30cm × 25 cm dimension) at 170^o C at atmosphere pressure, before pouring blend in open mould, releasing agent Teflon sheets are being put on mould and mould is heated at 150^o C for 30^{o}C.After pouring casting is heated at 170^{o+} C for 1 hour in hot air oven.

4) Post curing of castings: The casting has been heated at 170^o C for 4 hour. The main purpose of post curing is the blocking the active site of the cross linking i.e. to make sure that cross linking is 100%.

Table 3.1: Casting codes and their description.

Sl No.	Composite name	Code	Volume Friction of Glass: Kevlar; In between 65%.
1	Glass epoxy composite	G	100:0
2	Glass-Kevlar	H1	70-30
3	Glass-Kevlar	H2	45-55
4	Glass- Kevlar	H3	40-60
5	Glass- Kevlar	H4	25-75
6	Kevlar	K	0:100

For these composite resin percentage and thickness is same for all i.e. 35% and 4.5 mm.

B. Laminate preparation

1) Cutting of fibre layer: According to requirement the no of sheets, I have taken E-glass and Kevlar 29, fabric marked from the bundle and cut with cutter having 30mm×25mm size.

2) Compression Moulding Technique: This is a very common technique, especially for making laboratory specimens. In this process the fabric is coated with resin and then compressed in open moulds allowing the excess resin to flow out of the mould. Surplus fibers and excess resin are removed by cutting each end of the finished product. This wet moulding

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technique can still result in poor fiber distribution. Refining the manufacturing technique known as pre-pregging may reduce such difficulties. Here fabrics are coated with resin and are either wound onto a former or pulled through a die so as to form a web of material in which the fibers are parallel. The resin system is then partially cured so that the web stiffens and, when released from the former, continues to hold the fibers in desired place. Components are made from such web (also known as prepregs) by cutting out number of pieces in a mould. Silicone release agents (typically QZ 13) and 'Melinex" film is often used for easy release of the finished FRP products from the mould but I have taken Teflon sheets. The mould containing the prepregs is placed on the electric platen of a compression moulding press. The temperature of these platens is maintained at the curing temperature prescribed by the prepregs manufacturer. Some time is allowed to elapse between placing the mould on the heated platens and application of pressure for breathing. This time is technically known as dwelling time and it depends on the heat capacity of the mould and the quantity of the prepregs

IV. TESTING AND EVALUATION OF FRP COMPOSITES

A. Tensile Test

The tensile strength of the specimen is calculated from the maximum load and original area of cross section and expressed in force per unit area (N/m^2 or MPa). The percent elongation is the extension at beak divided by the original gauge length multiplied by 100. The modulus of elasticity (E) is calculated by extending the initial linear portion of the load-extension curve dividing the difference in stress corresponding to a certain section on the straight line by the corresponding difference in strain. All elastic modulus values are computed using the average initial cross-sectional area of the test specimen in the calculations. The results are expressed in MPa. Tensile Strength is given as:

$$\text{Tensile Strength} = \frac{\text{Load}}{b \times d \times 10.2}\ \text{MPa}$$

$$\text{Tensile modulus} = \frac{\text{Load}}{b \times d \times 10.2 \times \text{magnification factor(strain)}}\ \text{MPa}$$

Where:
b = Width of sample in cm
d = Thickness of sample in cm
Load = Maximum load applied to the sample
Length between two grips is taken as per ASTM slandered180 mm.
Crosshead speed = 4-4.5 mm/min.

B. Flexural Strength Test

Flexural properties, such as flexural strength and modulus are determined by ASTM test method D 790-84. Flexural strength is the maximum stress developed when a bar-shaped test piece, acting as a simple beam, is subjected to a bending force perpendicular to the bar. Composite beam specimen of rectangular cross section is loaded in either a three point bending mode or a four-point bending mode.
The flexural strength (S) is calculated from the following expression:

$$\text{Flexural strength} = \frac{1.5 \times \text{span} \times \text{Load}}{b \times d^2 \times 10.2}\ \text{MPa}$$

$$\text{Flexural modulus} = \frac{4 \times (\text{span})^3 \times \text{tangent Load}}{b \times d^3 \times 10.2 \times 2.54}\ \text{MPa}$$

Where
Load = Maximum load applied to the sample in Kg.
Span = 16×thickness of the specimen in cm
b = Breadth of sample in cm.
d = Thickness of sample in cm.
Data for the flexural modulus, which is a measure of stiffness, can be obtained by plotting stress versus strain during the test and measuring the slope of the curve obtained.

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C. Inter laminar Shear Strength (ILSS) Test

Inter laminar shear strength (ILSS) refers to the shear strength parallel to the plane of lamination. It is measured in a short-beam shear test in accordance with ASTM D 2344. A flexural specimen of small span-depth (L/h) ratio of 5:1 is tested in three point bending mode to produce a horizontal shear failure between the laminate plies. This test method is applicable to all types of parallel fiber reinforced samples.

$$\mathrm{ILSS} = \frac{0.75 \times \mathrm{Load}}{\mathrm{b} \times \mathrm{d} \times 10.2}\ \mathrm{MPa}$$

b = Width of the specimen in cm.
d = Thickness of the specimen in cm.
Load = Maximum load applied to the specimen in Kg.
Span length =5× thickness

D. Impact strength Test

Specification of Charpy impact strength & Izod impact strength is given in - ASTM D 256. A horizontal simply supported beam specimen is used. The energy absorbed in breaking the specimen, indicated by the position of the pointer on a calibrated dial attached to the testing machine, is equal to the difference between the energy of the pendulum hammer at the instant of impact and the energy remaining in the pendulum hammer after breaking the specimen.
The impact strength of the material under test is calculated from the following equation:

$$\mathrm{IS} = \frac{\mathrm{E} \times 10}{\mathrm{b} \times \mathrm{d}}\,\mathrm{K\,J/m^2}$$

Where:
E = Maximum energy absorb
b = Width of sample in cm
d = thickness of sample in cm
In the Charpy impact test, the specimen is supported as a horizontal simple beam and is broken by a single swing strike of the pendulum with the impact line midway between the supports and directly opposite the notch for notched specimens.

E. Burn-out Test

Five test specimens each having a size of 30 $\pm$ 2mm x 30 $\pm$ 2 mm shall be cut from different portions of the composite laminate and the sides of the specimens shall be square to the faces and the edges shall not be frayed.The specimen shall be weighed on an analytical balance in a previously weighed, ignited crucible. The crucible containing the specimen shall then be placed in a furnace at a temperature of not more than 343^{o}C. The temperature of the furnace at a temperature shall be raised to 565 + 28^{o}C at a rate that will not cause blowing, spurting or loss of resin. The specimen and the crucible shall be ignited at this maximum temperature to a constant weight (approximately for 4 to 6 hours), cooling in a desiccators between weighing.
The resin content (by weight) shall be calculated as follows:

$$\text{Resin content \%} = \frac{\text{Resin content}}{\text{Original weight}} \times 100$$

F. Thermo gravimetric analysis (TGA)

The thermal decomposition behavior of material is monitored by recording of blends weight change in a sample as a function of temperature. So, thermal degradation of blends and there composites were determined by thermo gravimetric analysis. The casting scrapes (power) were taken for TGA analysis. The experiments were carried out in N_2 atmosphere using Universal V4. 2E, TGA 2950 TA Instruments USA, ASTM D3418. The heating rate was 10°C /min and thermo grams were obtained as a plot of residual wt. against temperature. The sample was heated from room temperature up to 1000°C. The percent residual weight was calculated at 900°C. was calculated at 900°C.

$$\text{Residual weight} = \frac{\text{Wt. of the sample at particular temperature}}{\text{Origional wt. of material (scraps)}}$$

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V. RESULTS AND DISCUSSION

A. TGA Analysis

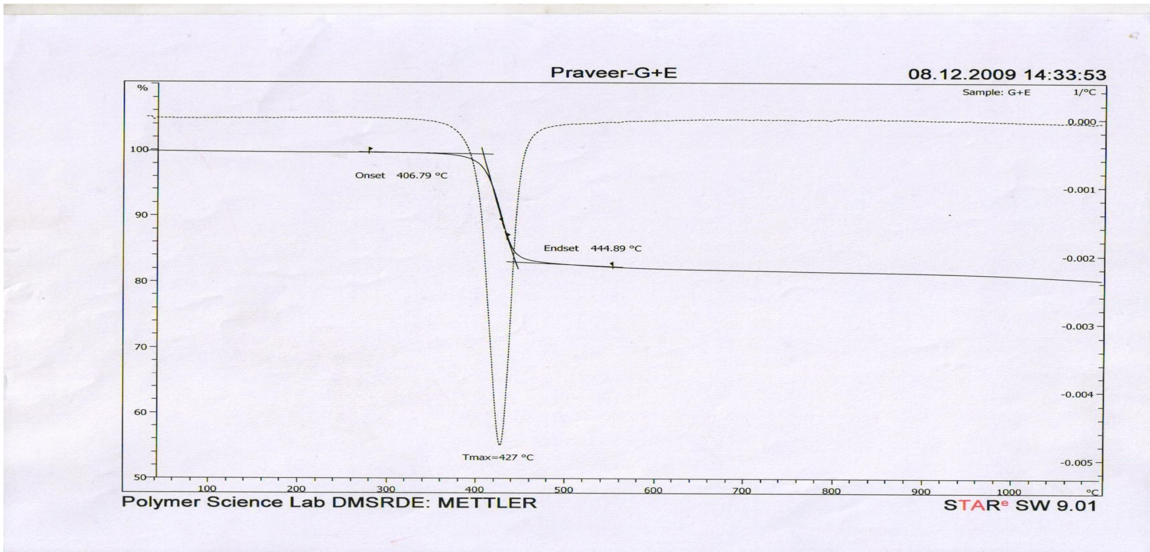

Figure 4.5: TGA tests for Glass epoxy composite

The above TGA trace shows that the composite system (matrix) is stable up-to 406.79 ^{0}C, only after which the weight reduction starts. Further, the residual weight of the composite remains unchanged by the increase of temperature indicates that the decomposable portion that is the epoxy resin is around 19% (≈30% by volume) which also confirms the amount of resin actually taken for the study.

The figure 4.5 indicates that the onset of decomposition is around 415^o C which is comparable to the trace of glass epoxy construction above as both the resin systems used were same with same hardener system .The further plateau indicates the decomposition of the organic fabric system which is Kevlar having the composition of Aromatic polyamide which exists at 434 ^{o}C through 449.81 ^{o}C. The last plateau exists at around beyond 605^{o}C exhibiting the stable char formation a desirable feature in the aircraft construction material.

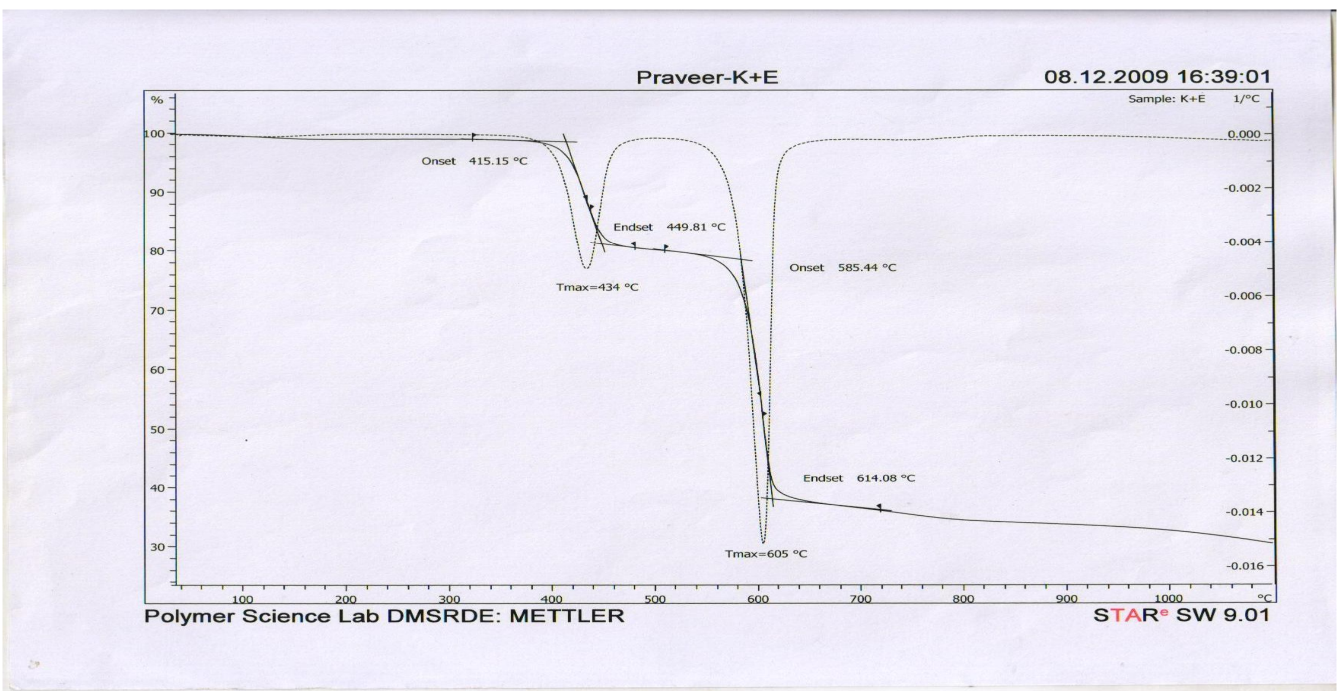

Figure 4.6: TGA test for Kevlar epoxy composite

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B. Tensile Test Analysis

Table 4.1: Tensile Strength (MPa)

Sr.NO.	Testing Code	G	H1	H2	H3	H4	K
1	TS1	280.5	250	218.6	230.3	200.9	181.75
2	TS2	304.6	246.5	214.1	226.47	210.7	186
3	TS3	289.8	241.8	210.02	235	203.5	186.8
4	TS4	296.2	239.6	217.08	233	200.7	184.5
5	TS5	288.6	245	215.6	224.9	209.5	184.75
--	Average	291.94	249	215.08	229.94	205.06	184.75

Table 4.2: Tensile modulus (G Pa)

Sr.No.	Code	G	H1	H2	H3	H4	K
1	TM1	29.6	24	24.65	21.2	21.2	19.9
2	TM2	29.7	25.2	23.4	21	20.1	19.7
3	TM3	30.1	26.3	24.3	23	20.9	20
4	TM4	29.8	24.3	22.65	23	21.9	20
5	TM5	29.8	25.2	22.5	22.27	21	20.4
--	Average	29.8	25	23.5	22.1	21.02	20

C. Flexural Test Analysis

Table 4.3: Flexural Strength (M Pa)

Sr.No.	Code	G	H1	H2	H3	H4	K
1	FS1	572.5	405.8	347.5	332	312.4	308.2
2	FS2	573.6	420.4	348.6	334.8	314.3	304.8
3	FS3	570.8	412	339.5	328.8	318.4	299.9
4	FS4	552.9	421.3	343.7	331.2	318.5	309.4
5	FS5	572.5	415.8	338.7	339.2	315.3	308.6
--	Average	568.6	415.06	341	332	315.76	306.8

Table 4.4: Flexural modulus (M Pa)

Sr.No.	Code	G	H1	H2	H3	H4	K
1	FM1	22.5	22	20	21.1	19.9	20
2	FM2	23.13	21.8	21	21.4	20	20
3	FM3	24	22	21	20.3	19.4	19.27
4	FM4	24	22	21.4	20.1	20.78	19.8
5	FM5	24.15	22.16	21.8	19.2	20.02	19.9
--	Average	23.6	22.16	21.04	20.42	20.02	19.79

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D. Inter laminar shear stress (M Pa) Test Analysis

Table 4.5: Inter laminar shear stress (M Pa)

Sr.No.	Code	G	H1	H2	H3	H4	K
1	IL1	41.9	35.5	28.8	25.8	19.4	15.7
2	IL2	45.5	30.8	23.3	23.8	18.2	16.9
3	IL3	42.7	34	30	26.9	20.75	13.8
4	IL4	36	38.8	27.1	23.4	20.47	14.6
5	IL5	41.8	33.5	27.8	27.6	23.7	14.6
--	Average	41.5	34.5	29.4	25.5	20.5	15.12

E. Impact Test Analysis

Table 4.6: Impact Strength ($KJ/m^{2)}$

Sr.No.	Code	G	H1	H2	H3	H4	K
1	IP1	175.5	183.9	200	240	285.8	314.8
2	IP2	177.77	177.3	192.3	244	288.5	316.5
3	IP3	167.9	185.8	203.2	245	287.3	310.9
4	IP4	170.9	175.9	201.2	235.5	284.2	318.1
5	IP5	177.5	182	198	239	284.3	313.5
--	Average	173.98	181.3	196.94	240.77	286.02	314.76

F. Interpretation of results

Fabricated composite of Glass/epoxy, Hybrid (Kevlar-Glass)/epoxy and Kevlar/epoxy were tested for their mechanical properties at room temperature by using different machine. For this 6 composite were fabricated and taken average value of 5 samples for each test. Results given below:

Table 4.7 deals with the laminate composition of 35% resin and 65% fabric by volume. The TGA trace enclosed as figure 4.5 & 4.6 shows that the sample actually after curing contained fiber around 71 % by volume and 29% is the resin (matrix) composites. (In which single type of fabric or is the combination of two types of fabric i.e. hybrid) in 65% it is taken the combination of fabric at different weight fraction.

As expected the properties can be varied by changing the volume fraction of the reinforcement and the optimum solution for the fatigue or the ballistic properties can be achieved. Further the cost aspects can also be controlled effectively without sacrificing the performance characteristics thereon. The values reported herein show a slight variance from that reported in the literature. This variance is due to the following reasons;

Table- 4.7 Results

1) Application of the matrix resin is through brush application and no flow promoters were available in the work station, hence the flow of resin has not been even.
2) The curing has been done without proper bagging or vacuum application, therefore, the volatiles which are formed during the process of curing are\ not removed effectively and the same may turn up into a void or a flaw reducing the strength of the laminate.
3) The press which was used did not had the facility for a controlled increase or decrease of temperature , hence the curing and the associated flow for the best performance as associated with the application to hi-tech areas such as Aerospace is achieved.
4) The curing schedule followed was the one provided by the resin manufacturer, as the data generated and optimized for the composite manufacture using this above mentioned resin system by the lab is restricted for safety reasons.

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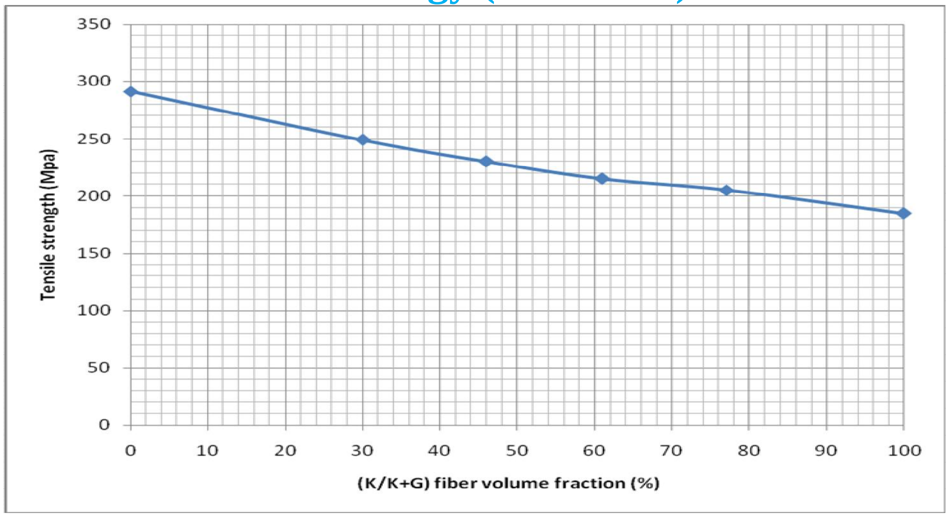

Figure 5.1: Tensile strength Vs variation of Kevlar fabric volume fraction

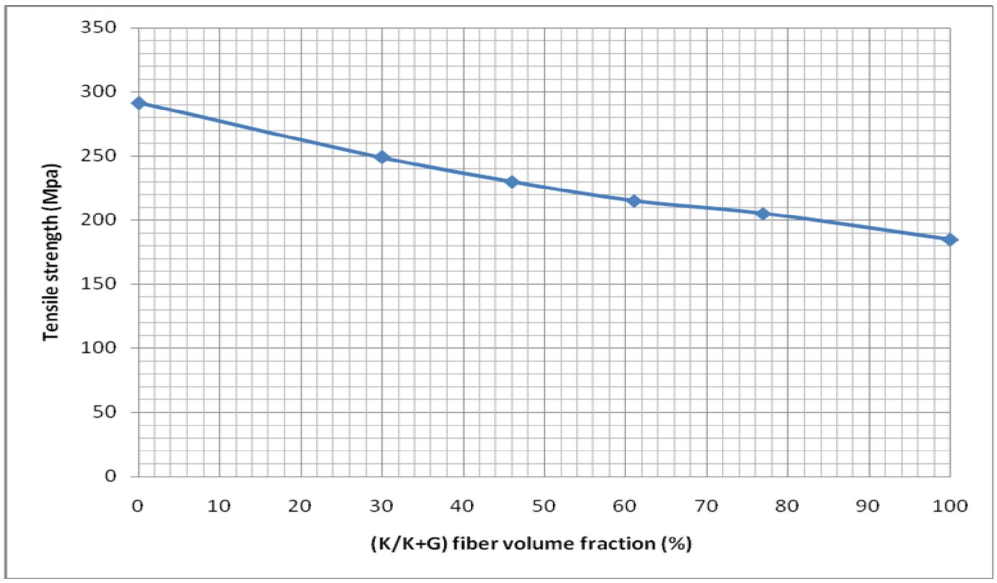

Figure 5.2: Impact strength Vs variation of Kevlar fabric volume fraction

Sr.No.	Code	Volume Friction of Glass: Kevlar; In between 65%.	Tensile strength (MPa)	Tensile modulus (GPa)	Flexural Strength (MPa)	Flexural Modulus (GPa)	ILSS (MPa)	Impact strength KJ/m^2
1	G	100:0	291.2	29.8	568.6	23.55	41.55	173.91
2	H1	30:70	249	25	415	22.16	34.5	181.3
3	H2	45:55	230	23.5	360	21.03	29.4	196.94
4	H3	60:40	215	22.23	332	20.4	25.5	240.77
5	H4	75:25	205	21.02	315.76	20.02	20.5	286.02
6	K	0:100	184.75	20	306.8	19.79	15.12	314.76

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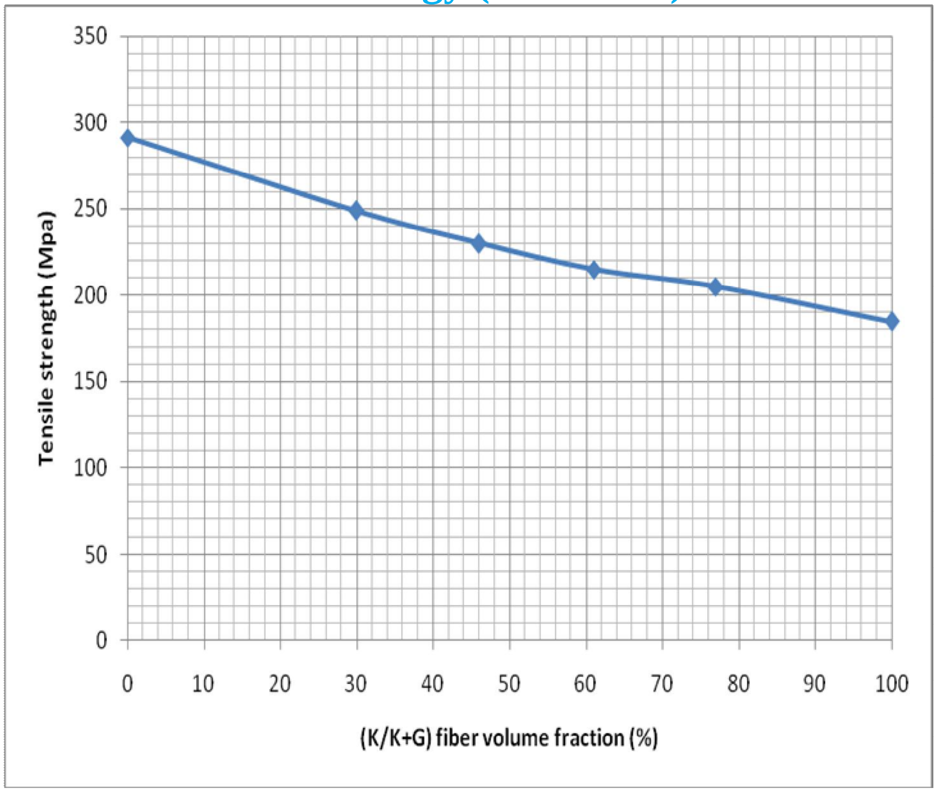

Figure 5.3: Tensile modulus Vs variation of Kevlar fabric volume fraction

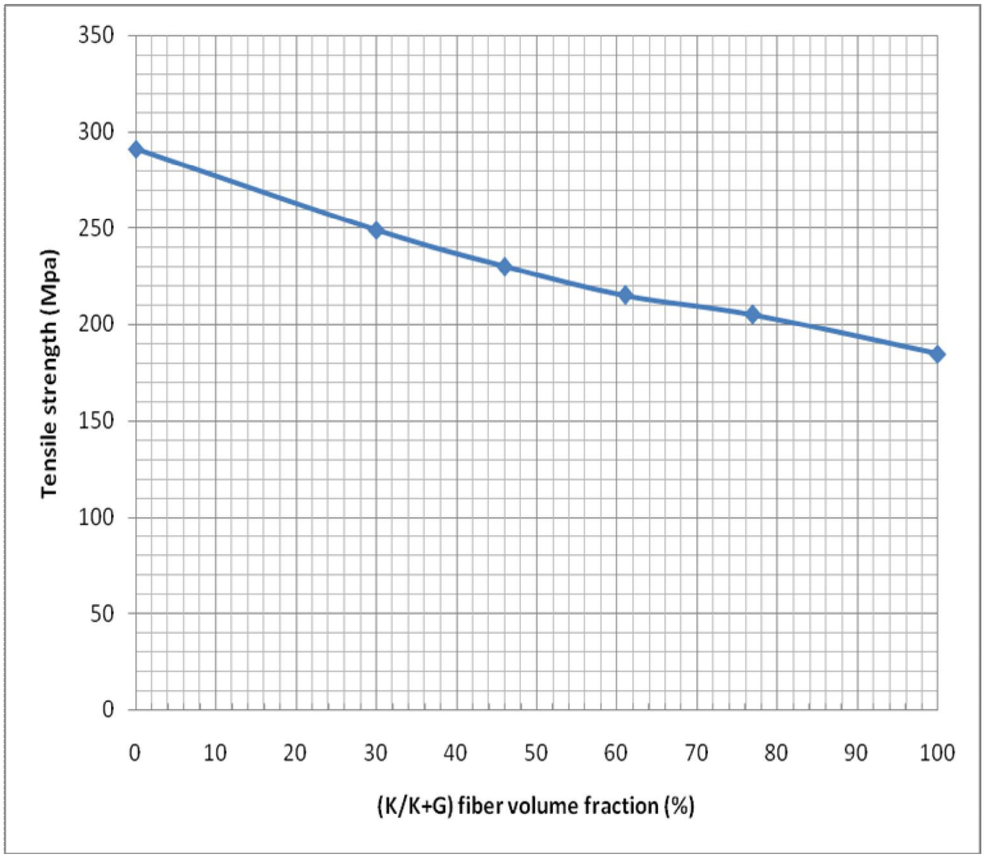

Figure 5.4: Flexural strength Vs variation of Kevlar fabric volume fraction

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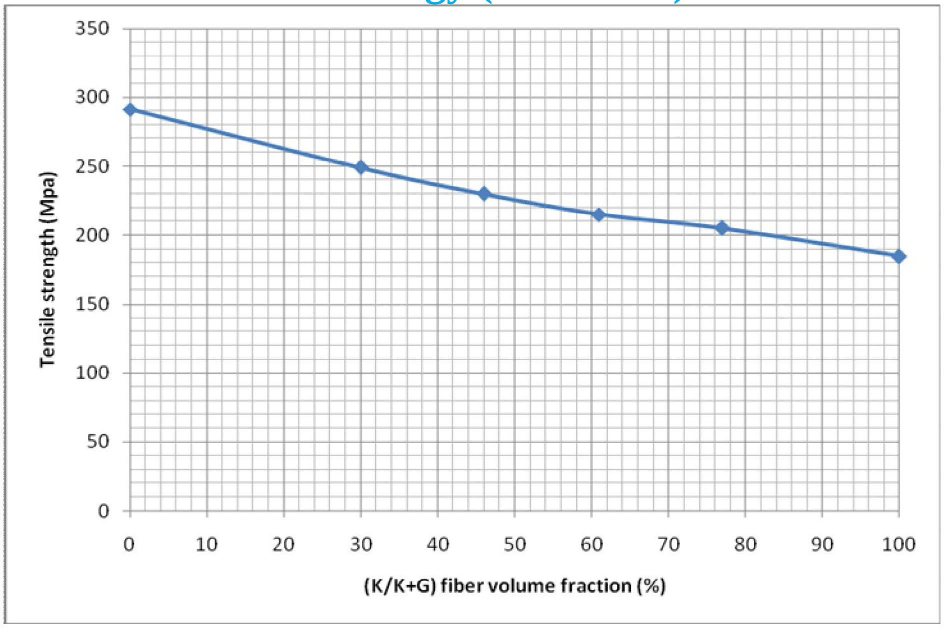

Figure 5.5: Flexural Modulus Vs variation of Kevlar fabric volume fraction

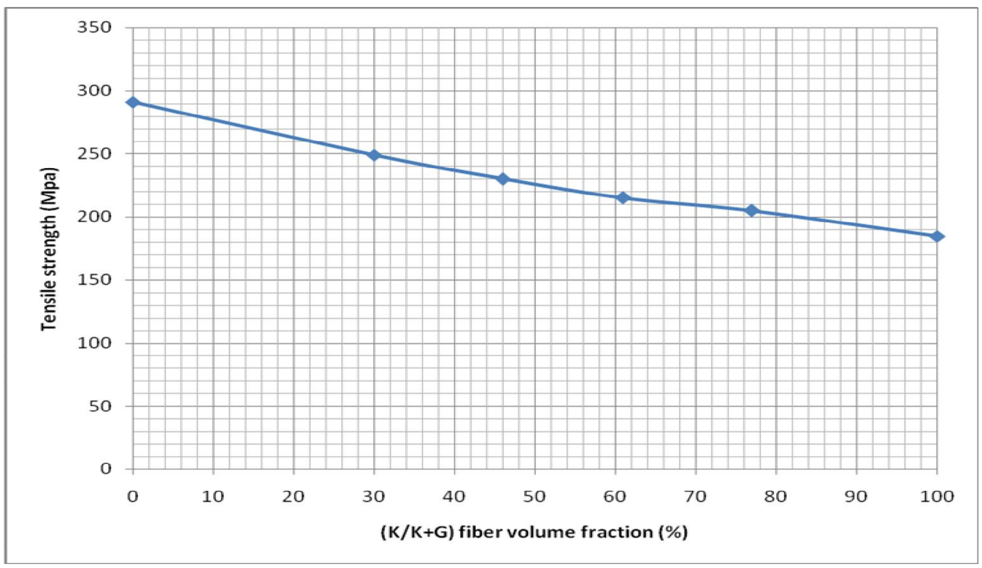

Figure 5.6: ILSS Vs variation of Kevlar fabric volume fraction

Discussion: Figure 5.1 indicates the variation of tensile strength by increasing the proportion of kevlar which is showing a downward trend. However, figure 5.2 indicates the increasing trend of impact strength with incresing the proportion of Kevlar, Figure 5.3-5.6 indicates the decreasing trends of the tensile modulus, flexural modulus, and flexural strength with increasing the proportion of kevlar.

With the increasing proportion of Kevlar cost also increases, hence critical damage tolerant composite construction for structural application and optimization can be achieved, for strength and toughness characteristics with optimization of cost Vs degree of damage tolerance and reliability by considering the inspection schedule. The damage tolerance structural material is in demand for high-tech and safety critical structural applications.

Hence the above study can be utilized to obtain the best combination of the composite construction consisting of more than one reinforcing material.

As is obvious from the literature cited above that hybrid construction can be more efficiently utilized from weight reduction consideration without compromising the performance and safety requirement. Hence this material can be used for aircraft structural

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applications where-in the damage tolerance can be built using kevlar and glass fabric reinforcement from the strength, toughness, maintainability, light weight and cost consideration. Further, for effective design the safety margins are built in the design of composite materials for aerospace applications in view of the flexibility to the production agency for accommodating a modification as per the user requirement or for technical upgrade of the system this safety margins also work on the uncertainties or the grey areas where the true assessment of the life of the composite materials cannot be predicted with greater accuracies with the analysis tools/ softwares available. This margin is above the safety factor which includes the degradation of material due environmental factors such as UV radiation, humidity, corrosivity of the environment, temperature of the service ambiance etc. Hence the consideration of strength margins is different in composites as comparted with metallic structures where-in the reparability of the structure has to look into the toughness and the strength considerations separately.

SEM morphology:

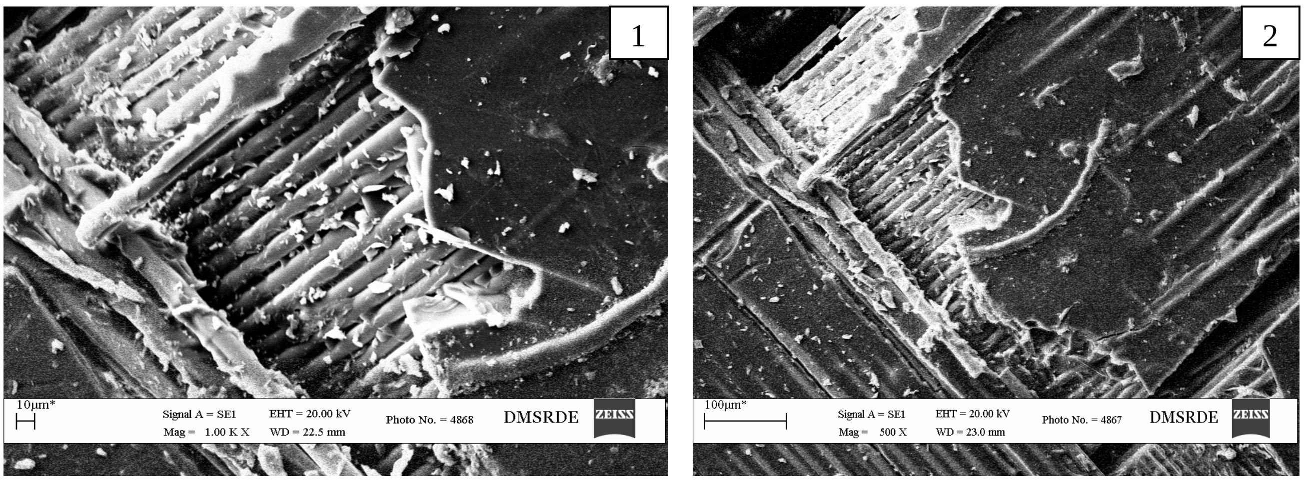

Figure 5.7: SEM images of the failed tensile specimen of Glass/epoxy composite used for conventional tensile.

From SEM-1 micrograph, we can observe strength and toughness characteristics with optimization of cost Vs degree of damage tolerance and reliability by considering the inspection schedule. The damage tolerance structural material is in demand for high-tech and safety critical structural applications Apart from this we can also observe the fiber brake at certain points which indicate the transfer from matrix to the fiber occurred during the loading. But this failure mode covers a small percentage. From SEM -2 micrograph we can observe matrix cracking and the fiber pull out from the matrix these two failure modes have significant contribution in tensile failure.

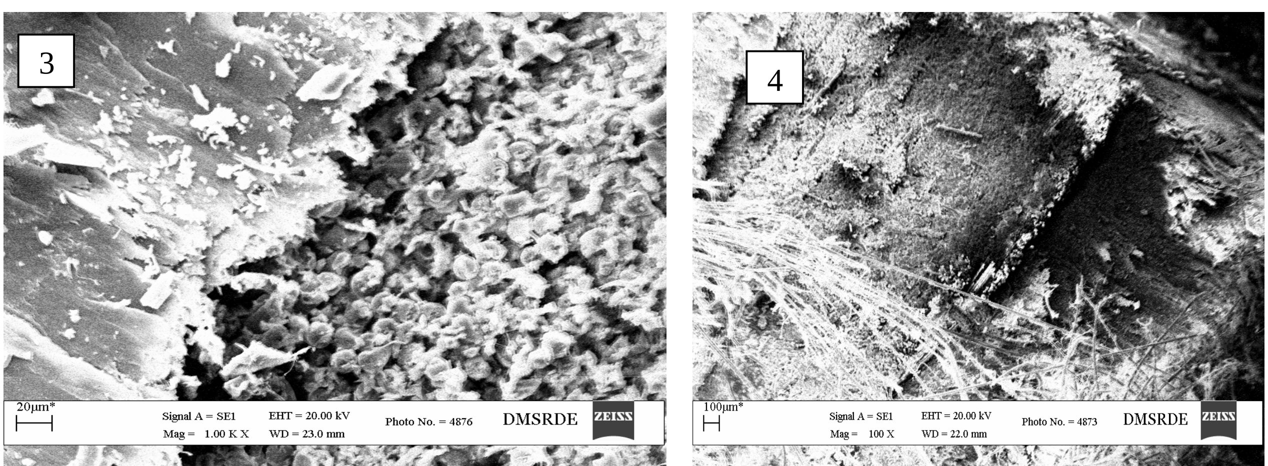

Figure 5.8: SEM images of the failed tensile specimen of Hybride-1 composite used for conventional tensile.

SEM 3-4 hybrid composite micrograph of tensile failure test sample revels the bonding
between the Glass and epoxy is better than Kevlar epoxy, deboning between the Kevlar fiber and the epoxy resin has been observed first matrix cracking have also been observed at the interface of Glass and Kevlar this lead to the deformation decrease in tensile

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strength of hybrid composite since the load transfer from epoxy to the Kevlar is poor.

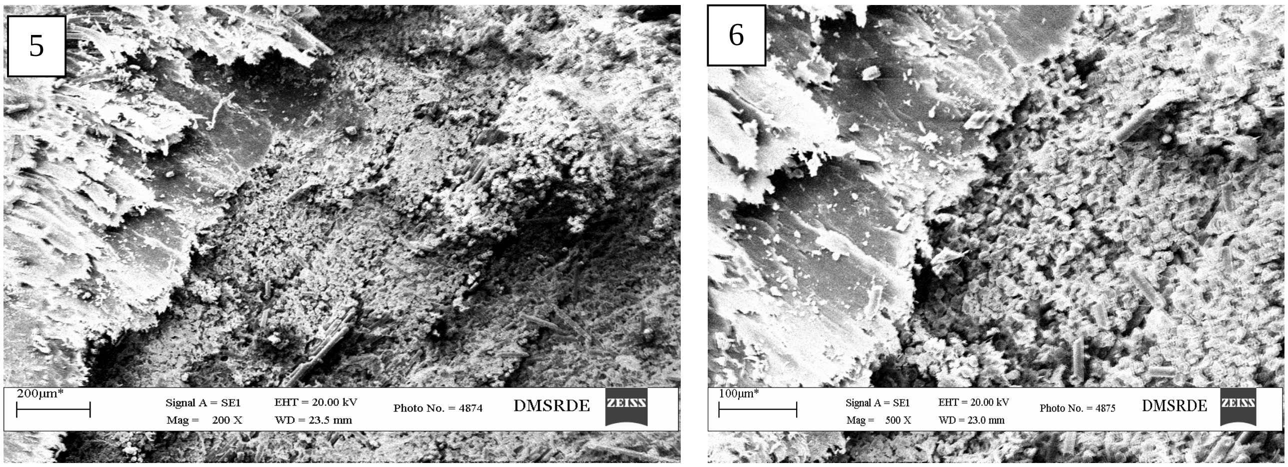

Figure 5.9: SEM images of the failed tensile specimen of Hybride-2 composite used for conventional tensile

SEM-5-6 It is clear that , due to the poor witting of epoxy resin of Kevlar matrix cracking have been dominantly result in ILSS test while the deboning between the glass and epoxy is the pairs to be better, due to this we have observe to decrease the value of ILSS.

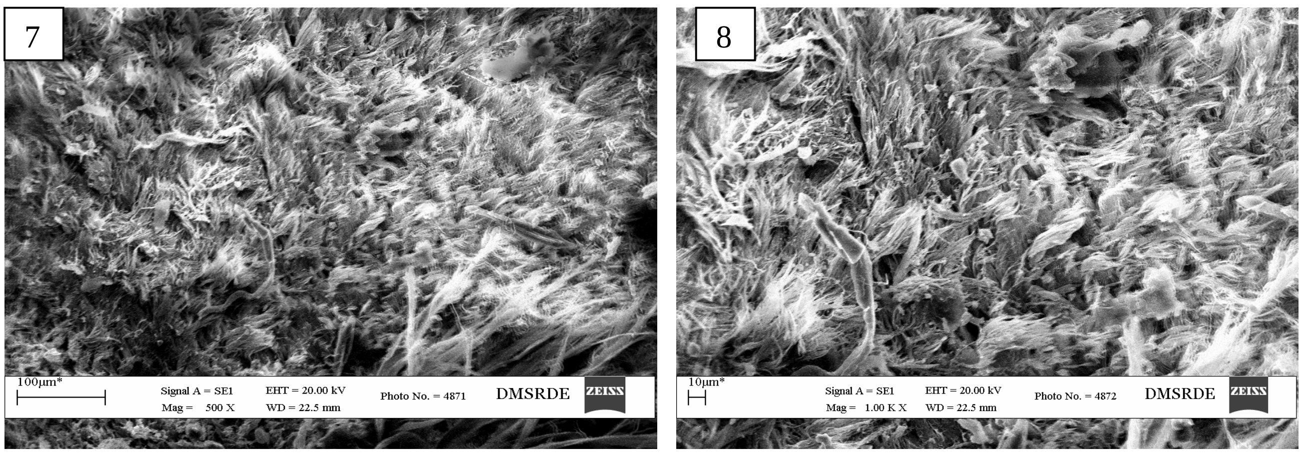

Figure 5.10: SEM images of the failed tensile specimen of Kevlar/epoxy composite used for conventional tensile.

In this SEM7-8 micrograph is very clear the fiber matrix deboning occurred to a very large extant and fibrillation which is one of the most important of the fabric has taken place a very small amount, which can be major load absorbing factor this has cause the poor value of tensile strength as compared to all previous composites.

VI. CONCLUSIONS

A. As discussed above the properties of the composite material not only can be achieved by varying the volume fraction of the fibers but can also be achieved by varying the type of reinforcement.

B. The use of more of glass fabric reduces cost of the laminates but detrimentally affects other desirable features of the engineered laminate.

C. Kevlar fabrics exhibit the phenomenon of fibrillation, thus showing a dramatic increase in the impact strength. Fibrils can be seen in the SEM micrograph of the fractured surfaces.

D. Tremendous weight savings can be achieved by using Kevlar when the resistance towards impact is required, a feature of utmost significance for aerospace where the designer has to struggle for each gram of construction to increase the valuable payload.

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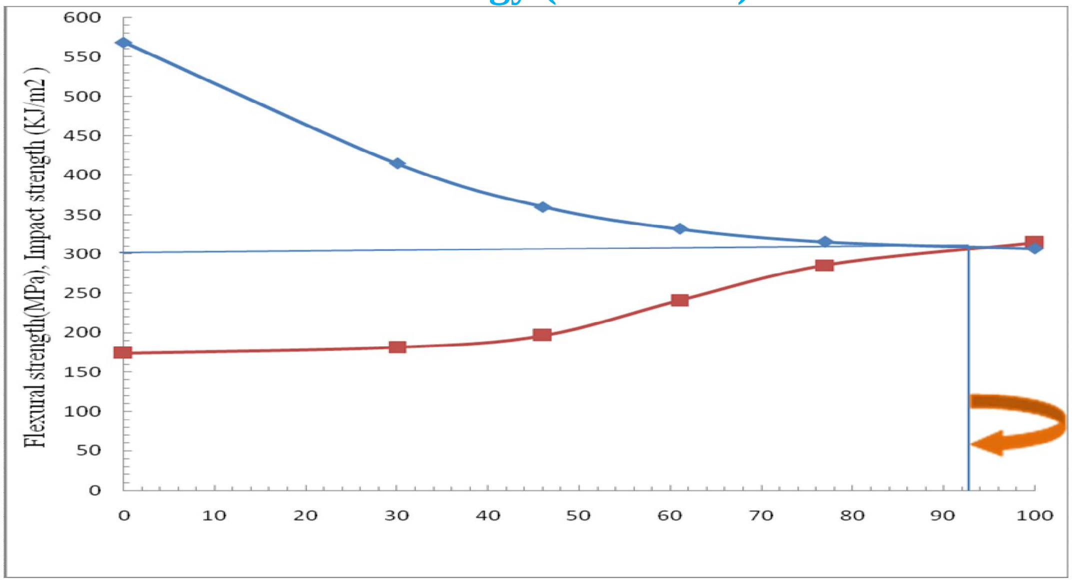

Figure 6.1 Composite trace of flexural and impact variance with hybrid composition

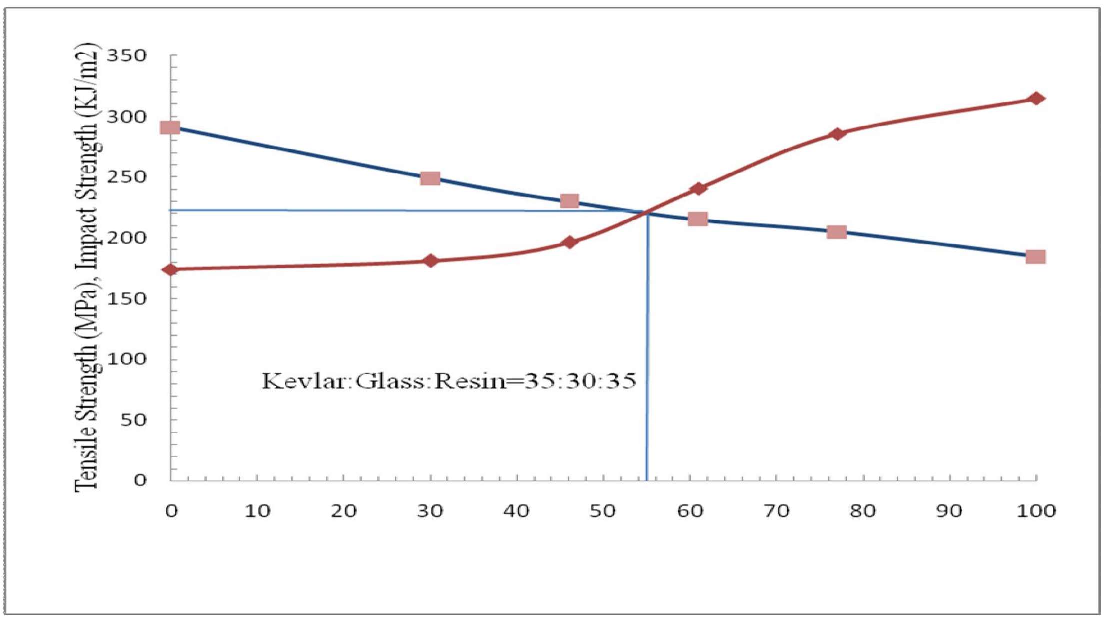

Figure 6.1 Composite trace of tensile and impact variance with hybrid composition

E. The above trace gives the compositional proportion of the point of best combination of properties. Nevertheless, the advantage of composites allows component wise designing or tailoring. Hence, the same can always be utilized for any specific component.

F. The compatibility of glass towards the epoxy matrix is higher compared to that of Kevlar epoxy. Hence a coupling agent should be used for achieving better performance of the construction by exploiting the maximum available strength / impact resistant feature.

G. The thermal stability of both the construction with Glass and Kevlar showed similar characteristics indicating it as a matrix governed phenomenon. Although the Kevlar exhibited a stable char yield a desirable feature during adverse conditions.

H. By the virtue of different chemical composition the hybrids can also be utilized for protection against the environmental deterioration of degradation or corrosion.

I. Consideration of the above factors apart from the can result in a safe, reliable, durable and maintainable design of critical structural load bearing components.

As found out and established in the development and evaluation of hybrid composites the strength and impact properties can be optimized using the hybrid construction and so the purpose of designing the above types of components for aircraft can be tailored to have the minimum weight with the desired levels of impact and strength along with other desirable properties such as low water absorption etc by having the desirable layup sequence such as use of glass fabric on the top layers to avoid ingress of moisture . The core hover made up of Kevlar will tremendously improve the impact behaviour at a much lower weight.

The study above clearly states that the designer has the additional flexibility of using a hybrid system of reinforcement for optimizing his material properties in terms of strength, life, maintainability, cost etc. by varying the fiber volume concentration and the type of the reinforcement as well.

REFERENCES

[1] Swanson, S.R. “Introduction to the design and analysis with advanced composite materials” TA 418,9C6S815 1997.
[2] Huang C P, Lee S W (2001).”Fabrication of composite” Composs part A, 28A:891-3.
[3] David Roylance, ”Introduction to Composite Materials” Department of Materials Science and Engineering, Massachusetts Institute of Technology, Cambridge ,2003.
[4] Mark B. Gruber, Mark A. Lamontia, and Brian J. Waibel “Automated ProcessFor Large Composite Aerospace Structures: A Trade Study” Accudyne Systems, Incorporated Newark, DE 19714.
[5] D. Thomas Campbell, David R. Cramer, ”Hybrid Thermoplastic Composite Ballastic Helmet Fabrication Study” Fiber-forge Corporation Glenwood Springs, Colorado 81601.
[6] Agrwal B.D. Broutman L.J. “ Analysis and performance of composite” second edition , john wiley & sons, Inc 1990.
[7] U P degraff, “Unsaturated polyester resin ” Handbook of composite , Von nastrand Reinhold Co. Newyark NY, 1982.
[8] J.R. Lawrence, Polyester Resin, Von nastrand, Reinhold Co.Newyark NY 1960.
[9] “Engineering material hand book” ASM international Volume 1; 1988.
[10] H.Warson and C.A. Frinch, “Application of synthetic Resin lattices, volume 2,Jons Wiley and Sons (canada) Lta 2001.
[11] K.Padmanbhar, Kishore, material Science & Engineering, 5 (1995) 1159-2275.
[12] P.N.B. Reis, J.A.M.Ferreira, F.V.Antunes, J.D.M.Costa; Part A: applied Science and Manufacturing 38(2007) 1612-1620.
[13] Jung-Kyu Kim , Ki,Weon kang: Composite Science and Technology; 61(2001) 135-143.
[14] C.Thomship; P.J. hogg; composite science and Tecnnology 63 (2003) 467-482.
[15] M.Bannister I.Hersberg, A Nicolaids, F.Coman, and K.H. leong composite part A; 29 A(1998) 293-315
[16] Comanho PP, Bowerons S,Matthews F.I. failure mechanism in bolted FRP, J Reinforcement Plastic Composite 1998;17: 205-238.
[17] K.Padambhusan Composite Part A, 27A (1996) 585-596.
[18] R.D.L.G. Sturgeen, Socity for advancement sparting Goods and material and Process Engineering, Covina, CA.ceedings.
[19] T.T.Sarafine “High Temperature resins” Hand Book of Composite . Van Nastrand, Reinhold Co.New Yark,NY, 1982,PP89-114.
[20] AminSele hi- Khojin,Reza Bashireza deh Muhmmad Mahinfaih,Reza Nakhaei-Jazar; Composites Pret B:37 (2006) 593-602.
[21] Current Science, Vol. 86, No3, 10, February 2004.
[22] Stephanie Kwolek, Hiroshi. Mara and Tardahiko takata, “High performance fiber” in ullmann’s Encyclopedia of industrial chemistry 2002, Wiley-VCH, Weinheim. Doi: 10.1002/14356007.a13_001.