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Fabrication and Testing of Aramid Fiber Reinforced Polymers

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***Abstract* - In the modernized world, Composite materials have been widely used in the aerospace and aeronautical applications. Composites are dominating the industry. The strength of the composites depends on the characteristics of the reinforcement and the matrix phases. Further addition of particles (Hardener) into the matrix enhances the overall properties and characteristics of the composite material. The current research involves the fabrication of the Aramid fiber reinforced composites with epoxy resin particles in the matrix using Hand lay-up process and Vacuum resin transfer molding (VRTM). Epoxy resin was selected as the base matrix that would be used. These composite specimens will be exposed to mechanical tests such as tensile, compression and flexural to observe the properties of the composites. The enhancement of the mechanical properties of the composite will be evaluated (practically).**

Keywords: Composites, Aramids, Hardener, Hand lay-up process, Tensile, compression, flexural.

INTRODUCTION:

In Aeronautical and Aerospace field weight is the most important factor. The designers have undergone research programmes and worked hard continuously to improve lift to weight ratios. Composite have played a major part in weight reduction. Composites are versatile in nature. They are found extensive use in automotive or transport, civil infrastructure, construction, sports and recreational equipment, tanks, ducts, hoods, electrical, marine, healthcare industry. Conventional materials have limitations in achieving a good combination of mechanical properties such as strength stiffness, toughness, and density. To overcome these shortcomings of present-day demand in modern day technology composites are most preferred materials in current use. Composites have mechanical and physical properties superior to most of the available conventional materials. Composites are having high strength and low weight, with corrosion resistance properties. They are very good insulators of thermal and electricity. They are also resistant to UV radiations, salt water, and chemicals. Nowadays innovative designs which are previously impractical are achieved with no loss in performance or strength.

METHODOLOGY:

SELECTION OF MATERIAL:

ARAMID FIBER:

Aramid is heat resistant and strong synthetic fibers. They are used in aerospace and military applications, for ballistic rated body armor, bicycle tires, and as an asbestos substitute. Molecules are linked by hydrogen bonds that transfer mechanical stress very efficiently, making it possible to use chains of relatively low molecular weight. The production of aramid fibers known under their trademark names Kevlar and Nomex. These two aramids are similar in basic structure. Kevlar is the Para-aramid and Nomex is the meta-aramid.

KEVLAR FIBER:

Kevlar is an organic fiber in an aromatic polyamide family. The unique properties and distinct chemical composition of wholly aromatic polyamides (aramids) distinguish them and especially Kevlar from other commercial, manmade fibers. It has a unique combination of high strength, high modulus, toughness, and thermal stability. It was developed for demanding industrial and advanced technology applications. Currently, many types of Kevlar are produced to meet a broad range of end uses. Kevlar molecules have an extended chain configuration and almost perfect crystalline packing. It is stronger than fiberglass and 5times stronger than steel. Benzene aromatic ring is the key structure of Kevlar's. It is chemically stable under a wide variety of exposure conditions, however, certain strong aqueous acids, bases and sodium hypochlorite can cause degradation. The further the pH deviates from pH7, the greater the loss in tenacity. The higher the relative humidity the faster Kevlar absorbs moisture during the initial phase of moisture gain, and the higher final equilibrium level. It does not melt but it decomposes at relatively high temperatures. Decomposition temperatures

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varying with the rate of temperature rise and the length of exposure.

A lot of development has been made in using Kevlar properties. It has predominantly entered many fields, but its poor compressible property requires innovations to be made to improve this.

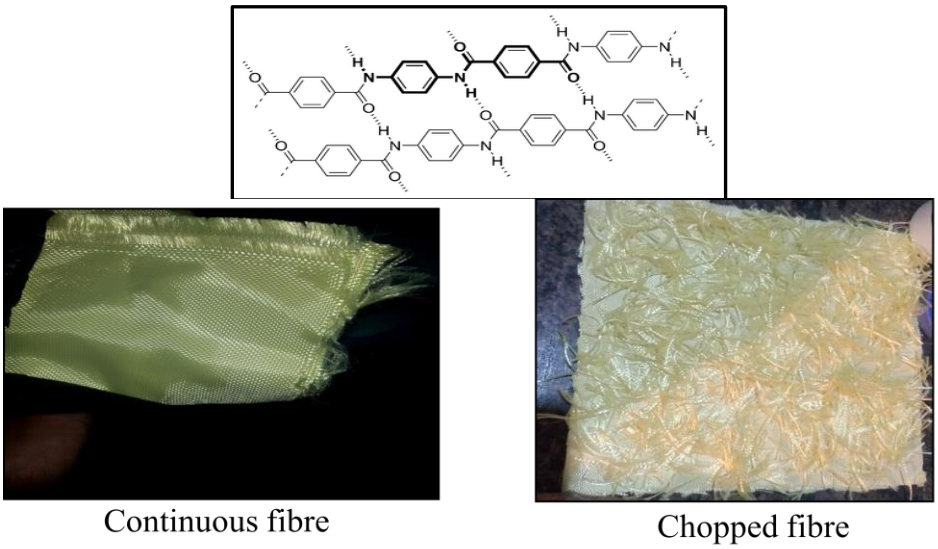

Figure 1: The molecular formula of kevlar and it's golden yellow state.

FABRICATION OF MATERIAL:

- The fabrication of the specimen was carried out using Hand lay-up process and Vacuum resin transfer molding.
- The Kevlar fiber was cut into 16 layers using Diamond scissors.
- Epoxy resin(LY556) was used as the base matrix along with hardener (HY951).
- One of the test specimens was fabricated using Continuous fiber reinforcement and the other one was done with a combination of continuous and chopped fiber reinforcement in the alternate layers.

Figure 2: Vacuum resin transfer molding and Fabricated material

- The specimens were cut according to the specified ASTM standards using Waterjet cutting. ASTM D4762 is the standard guide we have used.
- The specimens were cut by the water jet with abrasive at 3000 bar. Garnet sand was used as the abrasive.

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Figure 3: Garnet sand (abrasive), water jet cutting, cut specimens.

CALCULATION:

Table 1: Datasheet

Fiber	Kevlar 29 and Kevlar 49
Fiber diameter	12 µm
Fiber sheet thickness	0.2mm
Epoxy	LY556
Hardener	HY951
Fibre density	1.44 (g/cm^3)
Epoxy density	1.2 (g/cm^3)
Epoxy-fiber ratio	1:1
Epoxy-hardener ratio	10:1
Vacuum pump power	1/8 hp
Vacuum applied	670mm Hg (0.89 bar)
Vacuum time	90 minutes
Curing temperature	373k
Curing time	60 minutes
Machining	Water jet cutting

Table 2: Details of the fabrication of a specimen

Thickness of each sheet	0.2mm
Weight of each sheet	18 gm
Number of sheets drawn	16
Total weight of sheets	288 gm

U.V.TEST PROCEDURE:

Aramid materials are highly UV sensitive and excessive UV exposure results in a reduction of the ultimate compressive strength of fibers because of depolymerization and chain breaking. The UV damage procedure chosen to artificially damage the samples is prolonged exposure to UV radiation. Continous and prolonged exposure is harmful than an intermittent one because the dangerousness of the attack depends on the extent and degree of exposure. The polymers that possess UV absorption groups, such as aromatic wings can be sensitive to the effect of ultraviolet radiation and should be protected from the deleterious effects of sunlight. The damage caused by UV effects on this type of materials, which is visible after a long time exposure, can be evaluated by means of accelerated exposure testing.

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The experiment was conducted in the metrology laboratory. The UV lamp was mounted on a support with the metal tube used to direct most of the light towards the fiber sample. An open gap below the cylinder is to ensure natural air circulation during the test to avoid excessive temperature increase. The relevant feature of the UV lamp emission spectrum is the bright line around 300nm (in the UV region) because it happens to fall exactly on resonance with the critical wavelength of the unstable N-H bond of aramid fibers.

To measure the damage tolerance occurred due to UV light, the specimens were continuously exposed to UV radiation from the lamp for about 400 hours.

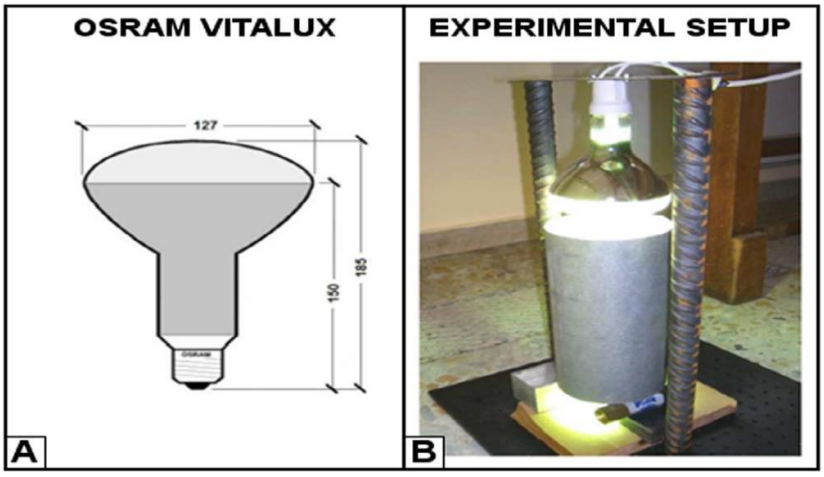

Figure 4: Technical details of Osram Vitalux lightbulb for scale comparison (A) and the experimental setup used to guide the light flux onto fiber samples (B).

TESTING:

The testing was performed and the results were obtained using a device known as Tensometer. A **Tensometer** is a device used to measure the mechanical properties of materials such as their Elastic Modulus (i.e. the degree to which they stretch under stress) and tensile strength. It is basically a UTM (universal testing machine) loaded with a material sample between two grips. The machine works either by a hydraulic ram or by driving a screw assembly. A material is gripped at both ends by an apparatus, which slowly pulls lengthwise on the piece until it fractures. The pulling force is called a load, which is plotted against the material length change, or displacement. The load is converted to a stress value and the displacement is converted to a strain value.

The Tensometer used in this case is PC 2000. It is a mini horizontal universal testing machine. It is a blend of state of art computer technology and precision manufacturing technique. The test is carried out and the online test graph is displayed on the monitor. Then the test is carried by gradually increasing the load and the displacement respective to the load is measured. The load versus displacement graph is obtained. Different results are obtained such as peak load, peak displacement, break load, break displacement, engineering UTS etc. From the obtained results the stress and strain values are calculated and finally, the Elastic modulus is calculated.

Figure 5: Tensometer

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Table 3: Standard Considerations

Load unit	N
Length unit	mm
Load Cell	20040N
Test Mode	Break
Test Speed	2mm/min
Length Increment	0.1mm
Proof Stress %	0.2

RESULTS:

TABLE 4: EXPERIMENTAL RESULTS FOR PEAK LOAD.

	0 HOURS		200 HOURS		400 HOURS	
	A	B	A	B	A	B
TENSILE	11621	12730	14592.8	10562.1	15485.25	8728.23
COMPRESSION	921.86	696.3	1971.207	608.034	951.279	519.771
FLEXURAL	284.39	451.12	353.052	470.736	284.403	715.911

TABLE 5: EXPERIMENTAL RESULTS FOR ULTIMATE STRENGTH.

	0 HOURS		200 HOURS		400 HOURS	
	A	B	A	B	A	B
TENSILE	225.656	203.848	293.896	174.832	293.838	143.852
COMPRESSION	76.715	24.893	61.699	19.790	54.838	15.613
FLEXURAL	13.021	6.492	13.822	7.574	14.324	8.640

Table 6: Compression strength for different hours of UV exposure.

	0 HOURS		200 HOURS		400 HOURS	
	A	B	A	B	A	B
COMPRESSION	76.715	24.893	61.699	19.790	54.838	15.613
PERCENTAGE	100	100	81.98	79.5	72.48	63.72

(A– Continuous FRP, B- Continuous and Discontinuous FRP)

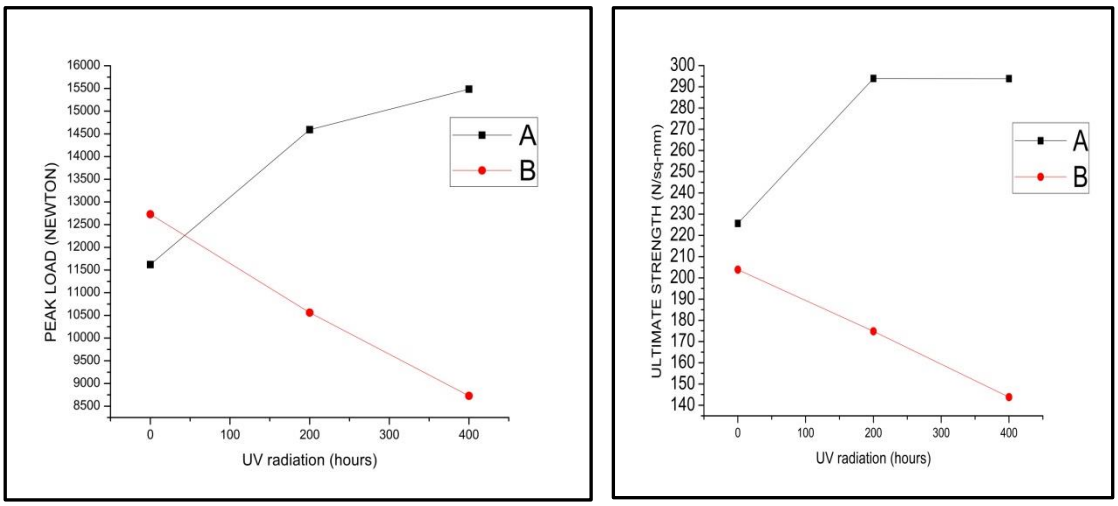

Figure 6: Tensile peak load and Ultimate tensile strength

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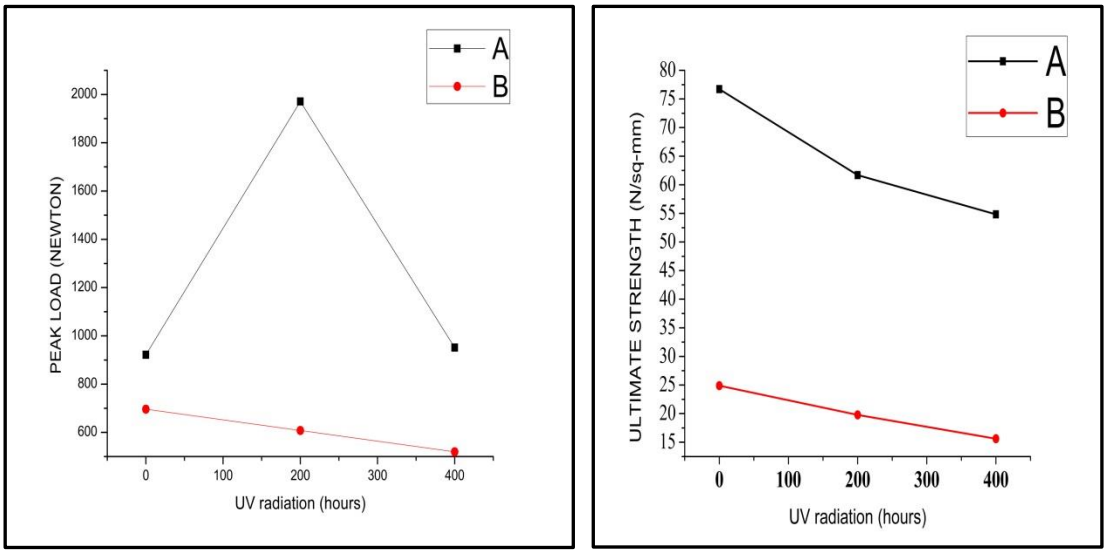

Figure 7: Compression load and Ultimate compression strength

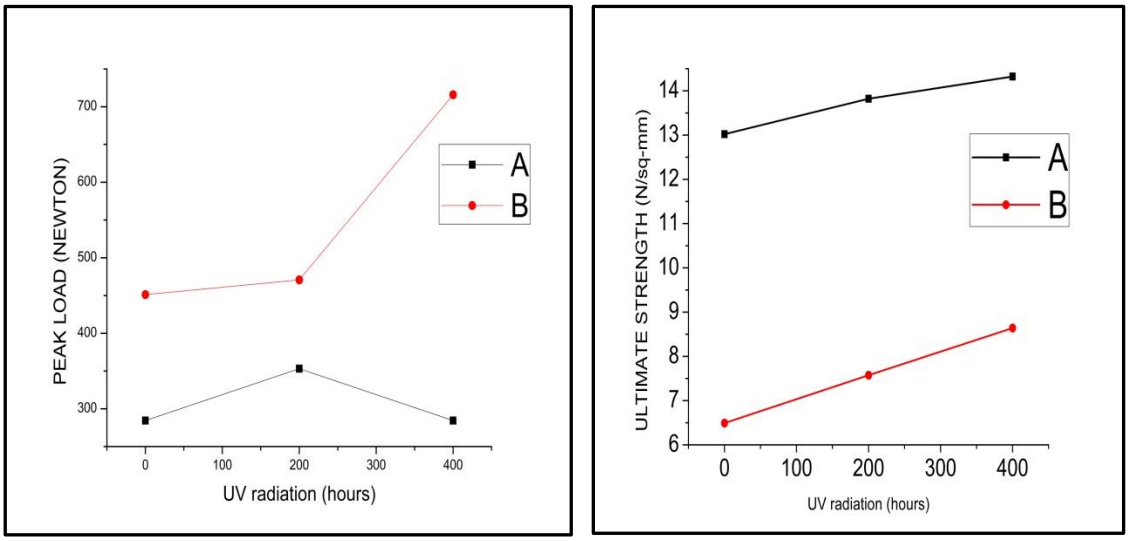

Figure 8: Flexural load and Ultimate Flexural strength

CONCLUSION:

This paper explored the possibility of assessing the damage caused on high- strength fibers by long-term exposure to radiation, with a low excitation resonant approach aimed at the measurement of materials mechanical characteristics. The samples of Kevlar 49 continuous FRP and Kevlar 29 continuous and chopped FRP's were exposed to different doses of UVA radiation, produced by a calibrated lamp in an accelerated aging experiment. The evaluation of their mechanical parameters was monitored by means of a universal testing machine, conceived for high-sensitivity dynamic measurements.

The experimental results showed that the material is sensitive to cumulated UVA radiation, increasing gradually the tensile strength while decreasing gradually the compression strength. This is undoubtedly due to the weak non-linear response of the material, as a result of the delaminating in the fabricated specimen. Using this parameter to assess cumulated damage occurred in Kevlar fibers from exposure to environmental UVA radiation should be considered seriously, implying a decrease in ultimate strength. Clearly, more sensitive methods might be devised, allowing even earlier damage in UV damage.

REFERENCES:

[1] Rosario Ceravolo, Andrea De Marchi, Elena Pinotti, Gecilia Surace, Luca Zanotti Fragonara - "Measurement of weak non-linear response of Kevlar fibre damaged by UV exposure" (2018) 807-813. (Journal ISSN: 0263-8223)

[2] Rumiya N. Kamalievaa, Ramaz V. Charkviania - "Creation of ultra-light spacecraft constructions made of composite materials".185 (2017) 190-197. (Journal ISSN: 1877-7058)

[3] Hemant Chouhan, Dilpreet singh, Vinod Parmar, Dinesh Kalyanasundaram, Naresh Bhatnagar – "Laser machining of Kevlar fibre reinforced laminates – effect of polyetherimide versus polypropylene matrix". (2016) 267-274. (Journal ISSN: 0266-3538).

[4] Suleyman Basturka, Haydar Uyanikb, Zafer Kazancib - "Nonlinear damped vibrations of a hybrid laminated composite plate subjected to blast load". DRaF2014 - 88(2014) 18 – 25. (Journal ISSN: 1877-7058).

International Journal of Engineering Research & Technology (IJERT)
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[5] Bendada, S.Sfarra, M. Genest, D. Paoletti, S.Rott, E. Talmy, C. Ibarra-Cistanedo, X.Maldague – "How to reveal subsurface defects in Kevlar composite materials after an impact loading using infrared vision and optical NDT techniques?". (2013) 195-208. (Journal ISSN: 0013-7944).

[6] Tien-Cuong Nguyen, Yu Bai, Xiao-Ling Zhao, Riadh Al-Mahaidi – "Effects of UV radiation and associated elevated temperature on mechanical performance of steel/CFRP double strap joints". (2012) 3563-3573. (Journal ISSN: 0263-8223).

[7] Kevlar technical guide – (http://www.dupont.com/content/dam/dupont/products-and-services/fabrics-fibers-and-nonwovens/fibers/documents/Kevlar_Technical_Guide.pdf).

[8] ASTM website (www.astm.org).