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COMPARISON AND TESTING OF HYBRID COMPOSITE MATERIALS FOR THE UNMANNED AERIAL VEHICLES

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Abstract: In the current days UAVs are growing at a rapid pace and they can be utilized in every sector, from defence to health. So for this we need to be advanced and forward in every aspect. This paper will guide you with the various types of materials and its properties for the application of UAV. We have combined them with each other and tried different hybrids to get the best results. Tested for various applications and then we have concluded a particular hybrid for a particular part. Choosing the right material is more important than choosing the right avionics because the materials are the backbone of the UAV. Various materials have their own different properties and it can be utilized smartly with proper knowledge of materials. We have tried to summarize the properties and tried to create the material guide for the new users so that they can manufacture the lightest and strongest UAV of the time.

Index Terms: **Carbon Composites, UAV Structures, UAV Materials, Hybrid Composites**

I. INTRODUCTION:

The UAV sector is a growing sector and Advanced UAVs are the future of humankind. Nowadays thousands of companies and the organizations are researching and manufacturing the UAVs for better lifestyle but the major loophole I observed about the UAVs are the structural part and the materials used in UAVs. Either the UAV is overweight, over strengthened or structurally failure; and the reason is optimization and use of appropriate materials for the particular part so that we can get the enough strength and low weight as possible so that we can get the lightest airframe. Therefore I conducted the research with the various composite materials and hybrid composite and then I evaluated the material and the hybrid for particular part of UAV. Here we first tested every possible material and the strength of part. We also analyzed the surface finish and the smoothness of the part so that we can get the lowest skin friction drag for the UAV.

II. LITERATURE REVIEW:

2.1 Introduction to Composite Materials and UAV Manufacturing

Composite materials are solid materials made up of a binder or matrix that encases and keeps reinforcements in place. The most important binders or matrices (both terms are regarded equal) in the marketplace are polymeric, and hence the ones covered in this book. Metal and ceramic matrix composites will also receive some attention. In general, fibers are used as reinforcements in all of these matrix materials. However, there will be some discussion of particle filled composites and nano fillers in their different forms [2]. A different definition of composites has been proposed by some authors: mixtures of two or more solid materials that are mechanically separable, at least in theory, and have complimentary qualities. This definition stresses the features that may be improved when composites are created. The more restrictive definition of composites proposed before fits within this other definition, and the complementing nature of matrix and reinforcement is why composites are so significant economically, as will become obvious [3].

2.2 Roles of the Matrix and Reinforcement in Composites

The matrix is the composite's continuous phase. Its primary function is to give the building form. As a result, matrix materials that can be easily formed and then maintained in that shape are particularly valuable. Polymers are the most frequent materials having this property. As a result, polymeric materials (also known as plastics or resins) make up the matrix of well over 90% of contemporary composites. The matrix surrounds and covers the reinforcements in the continuous phase. As a result, the matrix is the composite component that is immediately exposed to the environment. As a result, another function of the matrix is to shield the reinforcements from the environment. One of the most important factors to consider when selecting the kind of polymeric matrix for the composite is the required level of protection [4].

The reinforcement's primary function is to give the composite with strength, stiffness, and other mechanical qualities. In general, mechanical qualities are best in the direction of fiber orientation. When all of the fibers in a composite are orientated in the long direction of the portion (like strands in a rope), the composite will be the strongest when pushed in that direction. For a given application, a characteristic of composites allows the component designer to specify that a certain fraction of the fibers be in specific precise orientations. The designer would specify randomization or multi-directionality of the fibers if the stresses on the part came from all directions. Fiber orientation must be controlled by the composite component producer in order to meet fiber directional and percentage criteria [5].

2.3 Types of Fiber used for the UAV Manufacturing

Because of its low cost and simplicity of fabrication, glass-fiber reinforcement has found extensive usage in conjunction with thermosetting resins. As a result, it's used in secondary structures like fairings and primary structures on light-load aircraft in the general aviation and sailplane categories. The low elastic modulus of glass fiber is one of its drawbacks.

Glass Fibers Come in a Variety of Shapes and Sizes

Glass is an amorphous material made up of a silica (SiO2) backbone and a variety of oxide components that give it its unique compositions and qualities. Glass fibers come in a variety of shapes and sizes, but only four are employed in composites: E-glass, S-glass (and its variant S2), C-glass, and quartz are all types of glass.

As demonstrated in Table 8-2, S-glass is roughly 35 percent stronger than E-glass and retains mechanical qualities better at higher temperatures. In sophisticated composite applications when fiberglass is employed instead of one of the other high-performance reinforcements like carbon or aramid, S glass is favored.

Table 8-3 lists additional attributes for E-glass, S-glass, and C-glass. These findings highlight the benefits of E-glass in electrical applications and C-glass in acidic environments. Mineral quartz, which is mostly mined in Brazil, is used to make quartz fibers. The material is then formed into rods, which are finally pulled into fibers. Quartz has a 25 percent lower strength and a density that is just marginally lower than fiberglass.

2.3.1 Carbon-fiber-reinforced plastics (CFRP)

Carbon fibers are more costly than glass, but they provide a wider spectrum of material qualities. Carbon-fiber-reinforced plastic is the preferred material for many applications. The strength and stiffness qualities are outstanding, although it should be noted that values along the fiber direction are often an order of magnitude poorer than properties perpendicular fibers. To get the most out of carbon-reinforced polymers, you need a condition with a lot of stress in one direction, such in struts or along the flanges of beams.

As a result, carbon fiber materials are best suited to components with well-defined major load directions, such as aircraft lifting surfaces, and when the component is large enough to be made in one piece to remove joints. Other uses are feasible, but the benefits aren't as significant [6].

Carbon or graphite fibers were developed in response to a requirement for reinforcing fibers with greater strength and stiffness than glass fibers. Although Thomas Edison employed carbon fibers in his first successful electric light bulb, it wasn't until the 1950s that high-strength/high-modulus carbon fibers were developed. By the 1960s, rayon and polyacrylonitrile (PAN) fibers had been developed and commercialized sale [7]

. Pitch-based carbon fibers were created and marketed in the late 1960s. Carbon fibers' mechanical characteristics have constantly improved since then, thanks to advancements in starting materials and manufacturing techniques. Carbon/graphite fibers now have some of the highest specific strengths and specific modulus of any material [8].

There was a distinction between carbon and graphite fibers when they were first produced. Carbon fibers were processed through a high-temperature stage to create graphite fibers. (We'll go into the process of producing carbon/graphite fibers later.) Today, performance needs have mandated that all carbon fibers meet or exceed the performance capabilities of graphite fibers, therefore there is no distinction between the two types.

As a result, unless the graphite fiber classification is essential, such as when marketing and processing difficulties are mentioned, this book will use the phrase "carbon fiber" to refer to both fiber kinds. The modulus and strength specifications of each variation are now the emphasis of carbon fiber nomenclature [9].

2.3.2 Aramid-fiber-reinforced plastics

Aramid fibers, such as Kevlar, are strong yet have a low compressive strength. This is a significant disadvantage, thus aramid-reinforced materials are typically employed only where tensile stress or impact resistance are required. ARALL is an aluminum alloy ply with aramid-fiber reinforcement laminates.

Aramids are the most frequent organic fibers used for reinforcement, with Kevlar, a DuPont fiber, now being the most used. Other aramids are available, although they have not yet fully infiltrated the market. UHMWPE is another high-performance organic fiber. In the United States, this fiber is known as Spectra, whereas in Europe, it is known as "Dyneema." Other organic fibers could be employed as reinforcements in some applications, but not in high-performance ones [10].

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2.3.3 Polymers, Plastics and Resins

Polymeric, metallic, and ceramic matrix materials are all options. Polymer matrices are frequently referred to as plastics or resins. Some people in the composites sector interchangeably use all of these terms—polymer, resin, and plastic—while others distinguish between them. The term "polymer" refers to the way individual molecular units are bonded together to form a chain-like structure, with each unit acting as a link in the chain [12]. A monomer is a single molecular unit that can be converted into a polymer. Monomers are made up of atoms that are grouped in a specific and consistent way. When monomers are joined to form a polymer chain, the result is a single long chain known as a polymer molecule [13].

2.4 Reinforcement Forms

Spinning is a technique for creating single filament reinforcements. Filaments are commonly manufactured by running liquid raw material through a metal die with many holes, each hole forming a continuous filament, for efficiency. Precursor fibers are generated in this manner and then transformed in the case of carbon fiber. Despite the fact that most fiber reinforcements are made up of single filaments, single filaments are practically never used in composite or textile applications. Individual filaments are simply too delicate and tiny to be utilized. These single strands are sometimes referred to as monofilaments to underline their solitary nature.

A few words concerning the word "fiber" are appropriate here. This phrase is used in both technical and non-technical contexts. A single filament with a length that is significantly greater than its diameter is referred to as a precise definition. As a result, a fiber has a large aspect ratio. The name "fibers" is, however, a catch-all phrase for any single or collection of filaments with a high aspect ratio. Fibers are commonly considered to have a length of at least.20 in. in practice (0.5 cm). When synthetic fibers are manufactured, the material is called whiskers below that length, and they are usually continuous. This continuous nature makes it easier to process the fibers later in operations like weaving and knitting. However, there are times when having fibers that aren't continuous but are longer than whiskers is needed. As a result, the fibers are chopped into shorter lengths, usually between.50 and 4.00 inches (1.3 and 10.2 cm). Staple fibers are the chopped fibers that make up a carpet. These fibers are frequently combined with cotton or wool fibers in the textile industry, which are naturally in the length of staple fibers. Blending and co-processing are made easier when all of the elements in the blend are the same length [14].

In the United States, a yarn would be identified as, for example, ECG 150 3/2 3.0S, where this code represents the following:

- E stands for the type of glass (the example represents E-glass but others could use a C [C-glass] or S [S-glass] identifier).

- C denotes the filament type (the example is a continuous filament but others could be staple fibers and textured fibers).

- G denotes the filament diameter as defined by the standard designation. Because of their proclivity to break, fibers with diameters greater than K are rarely employed in composites.

- 150 is the number of filaments per pound (for example, 15,000 yards/lb). Rather than a precise number of filaments, the fiberglass is counted.

2.4.1 Woven and Knitted Fabrics (cloth)

To make discussing textiles easier, several directional norms have been devised. These norms, which date back to the dawn of weaving, are based on the way materials are woven on looms. Fibers are put in a parallel array on a loom between two supports during the weaving process. The warp, longitudinal, or machine direction is where the fibers are oriented. In most cases, the machine's orientation is 0°.

Other threads can be interlaced above and below the warp fibers if necessary. Manually interlacing the crossing strands is all that is required in early weaving. The interweaving procedure is highly mechanized in increasingly complicated looms. The weft refers to the interlaced, crossing strands. These fibers are oriented 90 degrees away from the machine direction.

Another option is to cut at a 45° angle across the strands. This is referred to as bias. Positive bias is the bias direction toward the right of the machine, whereas negative bias is the bias direction toward the left.

The same directional norms apply to rolls of cloth as they do to woven fabric. These are seen in Figure , which shows a roll of material. Fabrics are sometimes referred to as wide products, a word borrowed from the textile industry, because they are frequently marketed on rolls and are planar. The warp fibers are in the roll's long direction, while the fill or weft fibers are in the roll's cross or short direction.

2.4.2 Plain weave

Interlacing strands in an alternating over-and-under pattern creates the simplest of all weaving designs. In other words, this weave uses just one warp fiber for optimal fabric durability and firmness, with minimal strand slippage. When the strand size and count for warp and fill are the same, the pattern provides consistent strength in both directions. This weave is the most resistant to in-plane shear, and as a result, it is termed a rigid weave. Because the weave is robust, it is normally kept somewhat open, which allows for adequate resin penetration and air evacuation. Flat laminates, printed circuit boards, thin textiles, tooling, and covering wood constructions such as boats all employ plain weave fabrics.

2.4.3 Basket weave

Interlacing strands in an alternating over-and-under pattern creates the simplest of all weaving designs. In other words, this weave uses just one warp fiber for optimal fabric durability and firmness, with minimal strand slippage. When the strand size and count for warp and fill are the same, the pattern provides consistent strength in both directions. This weave is the most resistant to in-plane shear, and as a result, it is termed a rigid weave. Because the weave is robust, it is normally kept somewhat open, which allows for adequate resin penetration and air evacuation. Flat laminates, printed circuit boards, thin textiles, tooling, and covering wood constructions such as boats all employ plain weave fabrics.

2.4.4 Twill weave

It has the fill fibers cross over one and under two or more warp threads, giving the fabric a diagonal (bias) line look. When compared to plain weaves, this weave provides excellent wet-out and drape with only a minor compromise in stability. Because twill fabrics have less crimp, their strength is somewhat higher than plain weaves. Twill-based composites have a smoother surface than plain weave composites.

2.4.5 Satin or harness weave

One warp strand weaves across four or more strands (4 harness, 5 harness, 8-harness, etc.) then under one fill strand, similar to the twill weave. This weave offers a lot of elasticity and drape in all directions. It is feasible to get a high strand density. Satin weaves are smooth and flat. Satin weave is less stable than plain weave and less open than most other weaves, making wetting and air removal difficult unless a vacuum is utilized. Because the textiles are asymmetrical, special attention must be paid to the part's design to guarantee that asymmetric lay-ups do not cause warping.

2.4.6 Crowfoot weave

It is a satin weave that does not have a regular stagger pattern. This results in a weave that is more stable unidirectionally and stronger in the warp directions than a plain weave. The strand count in crowfoot and satin weaves might be greater than in plain or basket weaves. The fabric is very malleable, similar to other satin weaves, and can adapt to intricate forms and spherical shapes. Fishing rods, diving boards, skis, and aircraft ducts all employ the crowfoot weave.

2.4.7 Leno weave

Two parallel warp strands are twisted around each fill strand to create a locked effect in Leno weave. Low-count, open-weave cloth is less distorted with this weave. Heavy fabrics are also available allowing plies to be built up quickly. The inner core of the leno weave is utilized to sustain thin coatings, as well as tooling and repairs.

Weft knitting's looping design offers garments far more drape and elasticity than woven materials. As a result, these textiles' capacity to shape is extraordinary.

Knits' contouring ability has been effective in producing items with complicated geometry, like as electrical wiring and air conditioning ducts for airplane.

The knitted cloth may be worn as a sock over the mandrel, providing a well-fitting reinforcement with no effort. Knitted textiles are frequently employed in ballistic devices, especially when the device is highly formed, because the energy transmission inside the fabric is great (such as a helmet). Knitted materials' excellent crack-stopping power adds to this attractive attribute.

- In triaxial weaves, the warp fibers are moved into bias directions while the fill fibers are left in 90° directions. In the bias directions, these textiles offer a lot of strength. Triaxial weaves are particularly effective reinforcements in applications like as drive shafts, where the stress is mostly along the 45° axis.

They're also useful when combined with standard woven textiles to create a composite with excellent strength in all planes.

2.5 Non-Woven Fabrics (MAT)

Some composite applications may not necessitate the use of woven reinforcing. For example, a boat maker could be utilizing chopped fiber spray-up (described later in this chapter) but would prefer the ease of a sheet reinforcement. While switching to a woven cloth would undoubtedly improve physical and mechanical qualities, it would also be more expensive than using chopped spray-up. Chopped strand mat would be a cost-effective solution for the molder.

To make a material that can be handled as a sheet, a light layer of binder is applied and cured. The chopped strand mat provides the same level of reinforcement as spray-up, but with the added convenience of a lay-up fabric and a minor cost increase.

A woven cloth is more durable than a chopped strand mat. Because the fibers are loosely linked, some fibers may fall out of the mat when handled. As a result, considerable caution should be exercised when handling the product to ensure that the mat's integrity is preserved.

Advanced reinforcements like as carbon and aramid fibers are often used in woven textiles, but they are rarely used in chopped or continuous mats. These sophisticated fibers often need more accurate fiber direction control than matting can provide. Even the relatively stable geometry of textiles often results in some sub-optimal fiber arrangement. For example, in one application, 80 percent of the load may be in one direction. As a result, the designer wants 80 percent of the fibers to point in that direction so that the design is as efficient as possible.

Fabrics having 80% of their fibers oriented in one direction are uncommon and are unlikely to be stable enough for practical purposes. Another approach has been created that allows designers to maximize fiber orientation while maintaining the simplicity of fabrication of a sheet material. The procedure entails providing a sheet of fibers with all of the strands aligned in the same direction. The raw strands are loose and difficult to handle since they are not woven. Although the fibers might be coated with a little binder coating, another method of keeping them in place is presently favored. This approach involves coating the unidirectional fibers in matrix resin and then using the same quantity in the finished composite. As a result, these materials do not require any extra resin. The resin forms a film by holding the fibers together. Because the fibers are pre-impregnated with the matrix resin, these materials are called prepregs. Unidirectional tapes are prepregs with all fibers pointing in the same direction. Epoxy is commonly used to cover the fibers in prepreg sheets. It is partially cured (B-staged) and does not run off the fibers, making it simple to handle. No further materials may be added to the prepregs because the resin is already on the fibers. As a result, the resin coating must contain all of the hardening agent and other ingredients necessary for complete curing. The prepregs must be kept chilled to avoid premature curing since the resin covering contains everything needed to cure the resin. Prepregs are typically stored at 0° F (–18° C) for up to 6 months. Most prepregs must be recertified as acceptable or destroyed after that time. Because the length of time a prepreg spends at room temperature is essential to its shelf life, the time a roll of prepreg spends out of the freezer is carefully recorded. This is referred to as the roll-out-time. If the full roll is not finished on one outing, the remaining roll is returned to the freezer to extend the shelf life. Epoxy resins with substantially longer shelf life have been developed as a result of recent advancements in resin technology. Some report that even after a year without refrigeration, there has been no appreciable curing.

2.6 Hybrids

Hybrid materials are made up of two or more types of reinforcing. Carbon with aramid, glass with carbon, and glass with aramid are all good instances. The benefit of hybrids is that the better features of several reinforcing types may be used to improve the part's performance.

An I beam that will likely be exposed to impact is a very practical use. Figure 9-6 shows an example of a hybrid lay-up. Aramid fibers are inserted on the top and bottom of the I-beam in the places where impact is predicted, commonly as a prepreg sheet. Carbon fibers make up the rest of the I-beam. If the resins are the same, the aramid part should be able to be fully integrated with the carbon components. Other hybrids are created by laminating one material's sheet or cloth on top of another. Because energy dissipation is increased between layers of different materials, this has superior energy-absorbing qualities. Of course, delamination is a concern, but it may be mitigated if the resins used in the layers of various reinforcements are the same. Armor is a good example of how hybrids may be used. To provide the best performance in bullet-proof vests and stiff armor applications, layers of aramid and UHMWPE are alternated. Other hybrids are created by weaving or knitting various fibers together in the same cloth. This provides the benefit of enhancing the fabric's average qualities based on the average of the two components. Another benefit of this technology is that reinforcing fibers may be woven together with thermoplastic fibers, which can then be melted to produce the matrix. This removes the need for a separate matrix introduction, and the weaving pattern, of course, ensures that the matrix is spread evenly throughout the reinforcements (for example, making the reinforcement the warp and the matrix fibers the weft).

III. METHODOLOGY:

Step 1 –

Considering the Small autonomous UAV for the reference so that we test the material according to the strength required. So we considered the UAV with a wing span of almost 3m , with the aspect ratio of 9 and Maximum takeoff weight of around 15 kgs.

Now the strength of the UAV according to the reference is as follows

Fuselage - Belly part - It should be manufactured with the high Compressive and High Tensile at particular sections of the part, because all the electronics and the propulsion weight are carried by the fuselage.

Payload -If we are using the pods to carry the payload then the Pod will be connected to the fuselage, so we need to strengthen the fuselage accordingly.

Wings- As the UAV is carrying the high weight and lift generated will be also high but there are specific parts which require high strength only so focusing on it we need to use the materials particularly.

Tail - Tail generally stabilizes the aircraft but the force acting on the tail is quite high.

Step 2 -

Observing each and every material available and making any part out of it to test it.

Most importantly the hybrids and the sandwich method of composite are amazing as they need to be used with accurate precision.

Material 1 - Type 1

Glass Fiber - Plain Weave. –

We used a glass fiber cloth of plain weave of 100 grams per square meter for the tail part to check its strength.

We used the hand layup process to layup the cloth with the epoxy resin, and then used the vacuum bagging process to cure the part.We left the part for the 12 hours under vacuum and then after 12 hours we kept it in sunlight so that the bonding must be great.

Material 2 Type 1

Carbon Fiber - Plain weave Bi directional

We used the next material that is carbon fiber with the epoxy resin for the part using the process of hand layup. The cloth was of 100 grams per square meter and bidirectional. We used two layers of cloth and both in different directions (one in 90 degrees and other in 45 degrees).

Material 2 Type 2

Carbon fiber - Unidirectional.

We used the same process to layup and cure the part. It took us around 15 hours here because carbon fiber takes longer than glass fiber. As the part was cured we analyzed the part and tested it using the weights and noted the deflection. The part was strong and rigid but only in one direction because all the fibers were running in one single direction so it provides the strength in a single direction. The surface finish was not that good as we used hand lay-up. We can use the material for various parrots where we require strength in a single direction. Such as spars, stringers, longerons and many more.

Material 2 Type 3

Carbon Fiber - Twill Weave.

The material is quite similar to material 1 but the use is much different that the one. We can use this material for the larger parts. Such as fuselage skin.

Material 3 type 1

Kevlar - Plain Weave

Before testing the material we needed to set the material so we used the same process to make part out of kevlar and epoxy resin.

Kevlar took much long time to cure as it is denser than the carbon fiber and glass fiber. We tested the material for various situations.

And similar process was carried out on

Hybrid 1

Carbon Fiber + Glass Fiber (Carbon Fiber - Bidirectional and Glass Fiber - Bidirectional)

CF - 200 grams per square meter , GF - 100 grams per square meter

Hybrid 2

Glass Fiber + Kevlar (kevlar- Bidirectional Glass Fiber - Bidirectional)

Kevlar - 200 grams per square meter , GF - 100 grams per square meter

IV. RESULTS AND DISCUSSION:

Material 1 Glass Fiber

After releasing the part we observed and analyzed the part. The part was not strong at all to bear any airload. But the surface finish was really good for the UAV use and it will give very less skin friction drag.

Fig 1 Thickness of 100 grams per square meter Glas fiber

Observations

Cloth - 100 grams per square meter

Thickness - 0.07

Fig 2 Thickness of Cured glass fiber (3 layers)

After cure thickness - 0.09

Flexibility - too high

Strength - too low

Strength to weight ratio - not enough

Fig 3 Glass Fiber after cure

Fig 4 Rigdity of glass fiber

Material 2 Carbon Fiber –

Plain weave Bi directional

As soon as the part cured we released it and analyzed it. The part was strong enough to gold the airload and it can be used as skin but the surface finish was not good enough to make it smooth. We need to use the soft cut putty or body filler and that process increases the weight of the part. On the other hand the strength is too high for the airload

Fig 5 Thickness of carbon fiber 200 grams per square meter

Observations

Cloth - 200 grams per square meter

Thickness - 0.32

After Cure thickness - 0.4

Flexibility - low

Strength to weight ratio – high

Fig 5 As the surface finish was not enough we need to add soft cut putty for the good finish

As the surface finish was not enough we need to add soft cut putty for the good finish

Material 2 type 2 Carbon fiber Unidirectional

As the part was cured we analyzed the part and tested it using the weights and noted the deflection. The part was strong and rigid but only in one direction because all the fibers were running in one single direction so it provides the strength in a single direction. The surface finish was not that good as we used hand lay-up. We can use the material for various parrots where we require strength in a single direction. Such as spars, stringers, longerons and many more.

Fig 6 Carbon fiber UD thickness

Observations

Cloth - 200 grams per square meter

Thickness - 0.3

After Cure thickness - 0.4

Flexibility - very low in one direction and high in other

Strength to weight ratio - depends on the direction you are applying.

Material 3 Type 1

Kevlar Plain Weave

At first the surface finish was too bad for the UAV but on the other hand the strength is too high but as well as weight. So choosing this material is quite complex as in various tests the material failed in compression. So we can use kevlar in various parts of UAV such as on the belly of the fuselage but with the solution to smooth the surface. We use kevlar on the belly just because we can’t use carbon fiber as it interrupts various electronics to work efficiently.

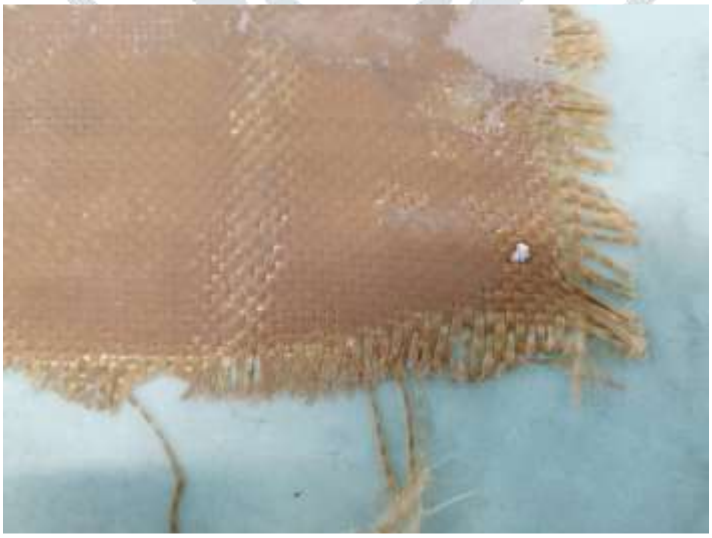

Fig 7 Cured kevlar

Fig 8 thickness cured Kevlar

Observations

Cloth - 200 grams per square meter

Thickness – 1.6

After Cure thickness – 1.18

Flexibility - very low

Strength to weight ratio - Good enough.

Hybrids

As we observed that if one material is good in strength but not good enough in surface finish and vice versa so to solve the issue we tried using the hybrid for various parts and tested the sample.

Hybrid 1

Carbon Fiber + Glass Fiber (Carbon Fiber - Bidirectional and Glass Fiber - Bidirectional)

CF - 200 grams per square meter GF - 100 grams per square meter

Process to set - Same as before

The sample part was as expected the surface finish was too good compared to carbon fiber and the strength was also good enough. Weight is reduced a lot and the results are good enough for the applications. We can use this hybrid for the skin of wings and tail.

Fig 9 Surface Finish of Hybrid 1

Fig 10 Thickness of Hybrid 1 (Carbon fiber + Glass fiber)

Hybrid 2

Glass Fiber + Kevlar (kevlar- Bidirectional Glass Fiber - Bidirectional)

Kevlar - 200 grams per square meter GF - 100 grams per square meter

The sample part was as expected the surface finish was too good compared to kevlar and the strength was also good enough. Weight is reduced a lot and the results are good enough for the applications. We can use this hybrid for the skin of the belly of the fuselage and the Pod.

Fig 11 hybrid 2

V. CONCLUSION:

After testing the various material and hybrid of it results are good enough for the application and the current problem of UAV can be solved by using the proper hybrid for the specific part such as For the fuselage- For upper portion we can use one layer of glass fiber (100 grams per square meter) and two layers of carbon fiber (200 grams per square meter) For Belly we can use the one layer of glass fiber and Two layers of kevlar. For the Wing Skin We can use glass fiber and Carbon fiber one of each. Spars, Stringers can be made out of carbon fiber unidirectional only. Hybrid of composite material is the solution for current problem. UAVs are the future of human society. Every sector needs and will rely on UAVs for transportation. So materials will play a crucial and major role in manufacturing and UAV science. Composite materials are the best materials with the high strength to weight ratio but we can improve the efficiency with utilization of their right properties at the right time. Hybrids will be better versions of UAV and can be used for various purpose.

REFERENCES:

[1] Sullivan, R., Rais-Rohani, M., Lacy, T., & Alday, N. (2006). Structural testing of an ultralight uav composite wing. In *47th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference 14th AIAA/ASME/AHS Adaptive Structures Conference 7th* (p. 1870).

[2] Sullivan, R. W., Hwang, Y., Rais-Rohani, M., & Lacy, T. (2009). Structural analysis and testing of an ultralight unmanned-aerial-vehicle carbon-composite wing. *Journal of aircraft*, *46*(3), 814-820.

[3] Simsiriwong, J., & Sullivan, R. W. (2010). Vibration testing of a carbon composite fuselage. *International Journal of Vehicle Noise and Vibration*, *6*(2-4),149-162.

[4] Smith, H. W. (1988). Static test of an ultralight airplane. *Journal of Aircraft*, *25*(1), 37-40.

[5] Wong, A. K., & Luke, G. (1996). *The Static Testing of a Lockheed P-3 Orion Wing Leading Edge Centre Section*. DEFENCE SCIENCE AND TECHNOLOGY ORGANIZATION CANBERRA (AUSTRALIA).

[6] Bertin, J. J., & Cummings, R. M. (2021). *Aerodynamics for engineers*. Cambridge University Press.

[7] Devi, G. R., & Rao, K. R. (1993). Carbon Carbon Composites: An Overview. *Defence Science Journal*, *43*(4), 369.

[8] Neumeister, J., Jansson, S., & Leckie, F. (1996). The effect of fiber architecture on the mechanical properties of carbon/carbon fiber composites. *Acta materialia*, *44*(2), 573-585.

[9] Chung, D. D. L. (1994). Carbon fiber composites Butterworth.

[10] THOMAS, C. R. (1993). Essentials of carbon-carbon composites. *Roy. Soc. Chem.*

[11] Sogabe, T., Nakajima, K., & Inagaki, M. (1996). Effect of boron-doping on structure and some properties of carbon-carbon composite. *Journal of materials science*, *31*(24), 6469-6476.

[12] Lu, W. (2001). *Modification of carbons for structural, environmental, thermal and battery applications*. State University of New York at Buffalo.

[13] Haque, A., Copeland, C. W., Zadoo, D. P., & Jeelani, S. (1990). Hygrothermal influence on the flexural properties of Kevlar-graphite/epoxy hybrid composites. *Journal of reinforced plastics and composites*, *9*(6), 602-613.

[14] Peijs, A. A. J. M., Venderbosch, R. W., & Lemstra, P. J. (1990). Hybrid composites based on polyethylene and carbon fibers Part 3: Impact resistant structural composites through damage management. *Composites*, *21*(6), 522-530.