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# Structural and mechanical analysis of graphene coated aluminum alloy sheet

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**ABSTRACT**

Aircraft is the fastest moving vehicle available for Transport of Passengers, materials and for war applications. Composite materials are the most important part of aircraft as it protects the aircraft from bad weather condition and to maintain the temperature. Now-a-days most of the parts like Fuselage, wings etc of the aircraft are being done by using composite materials. But, still there are many problems and the aircraft are getting damage. The aircraft manufacturers, mainly accuses of bad. This paper gives brief explanations about the composite materials & Graphene and how it can be used for further/future aircrafts. The Paper also deals with the activities involved with manufacturing composites in the honey comb shop of aircraft division, HAL. The first section of the Paper explains the various type of Composite materials (Kevlar, Carbon fiber & Graphene), Introduction of the materials, properties & applications and the various test methods. It explores the possibility of using the upcoming material Graphene in Aircraft constructions. It has been proven that graphene has insulating properties that are both electrical & thermal in nature. Hence, the testing is being done for the Aluminum plate by using graphene as the protective layer.

**KEY WORDS:** Graphene with Al coatings, NDT testing, Kevlar, carbon fibers.

## 1. INTRODUCTION

In this research structural and mechanical analysis of aluminum with graphene coatings at different proportions and with different other materials coatings on aluminum were done. The results were tabulated to get suitable material.

## 2. METHODS & MATERIALS

**Properties of Materials Used:**

**Graphene Properties:**

Density : 0.77 kg/m3
Tensile Modulus : 1000GPa
Tensile Strength : 5GPa
Melting Point : $3650^0$C
Critical Temperature : $681^0$C
Bond Length : 0.142nm
Young's Modulus : $152x10^6N/m^2$

**Carbon fiber properties:**

Density : $1.60Kg/m^3$
Tensile Strength : 110MPa
Young's Modulus : $26.3x10^6N/m^2$

**Kevlar Properties:**

Density : $1.47Kg/m^3$
Tensile Modulus : $186N/m^2$
Tensile Strength : 3.4GPa
Tensile Elongation : 2.0%
Young's Modulus : $16.3x10^6N/m^2$

**Coating and Bonding Process of the Materials:**

**1g of Graphene:** Aluminum plate has to be anodized and primed. 1 gm of graphene (GO) has to be mixed with 25grm of epoxy resin (AY103) and hardener (HY951). Keep it in room temperature for curing.

**2g of Graphene:** Aluminum plate has to be anodized and primed. 2 gm of graphene (GO) has to be mixed with 25gm of epoxy resin (AY103) and hardener (HY951). Keep it in room temperature for curing.

**Resin and Hardener-Only cleaning:** Aluminum plate has to be cleaned in dyechloro ethylene. Resin (AY103) and hardener (HY951) of 25gm has to be coated and leave it for curing in room temperature.

**Kevlar k285:** Aluminum plate has to clean in dyechloro ethylene. Fm 73 bonding material is applied in the aluminum plate. On top of FM 73 the Kevlar sheet is applied. Then the plate is kept for curing in autoclave molding for bonding.

**Carbon Fiber G801:** Aluminum plate has to clean in dyechloro ethylene. FM 73 bonding material is applied in the aluminum plate. On top of FM 73 the carbon fiber sheet is applied. Then the plate is kept for curing in autoclave molding for bonding.

**NDT Testing Method**

**Liquid Penetrant method:** Liquid penetrant testing is one of the oldest of modern nondestructive testing methods & widely used in aircraft maintenance. Liquid penetrant testing can be defined as a physical & chemical nondestructive procedure designed to detect & expose surface connected discontinuities in 'nonporous' engineering materials. The fundamental purpose of penetrant testing is to increase the visible contrast between a discontinuity & its background.


**Figure.1.Various Penetrants used**

**Magnetic Particle Method:** Magnetic particle testing is a sensitive method of nondestructive testing for surface breaking and some sub-surface discontinuation in 'Ferro-magnetic' materials. The testing method is based on the principle that magnetic flux in a magnetized object is locally distorted by the presence of discontinuity. This distortion causes some of the magnetic field to exit & re-enter the test object at the discontinuity. This phenomenon is called magnetic flux leakage. Flux leakage is capable of attracting finely divided particles of magnetic materials that in turn form an 'indication' of the discontinuity. Therefore, the test basically consists of three operations: a) Establish a suitable magnetic flux in the test object by circular or longitudinal magnetization. b) Apply magnetic particles in dry powder of a liquid suspension; and c) Examine the test object under suitable lighting conditions for interpreting & evaluating the indications. Fluorescent or black oxide particles in the aerosol cans are used during critical areas of aircraft structure/components inspection when using either permanent or electromagnets. Fluorescent particle inspection method is evaluated by black light (Black light consists of a 100 watt mercury vapor projection spot lamp equipped with a filter to transmit wave length between 3200 to 3800 Angstrom unit and absorb substantially all visible white light).

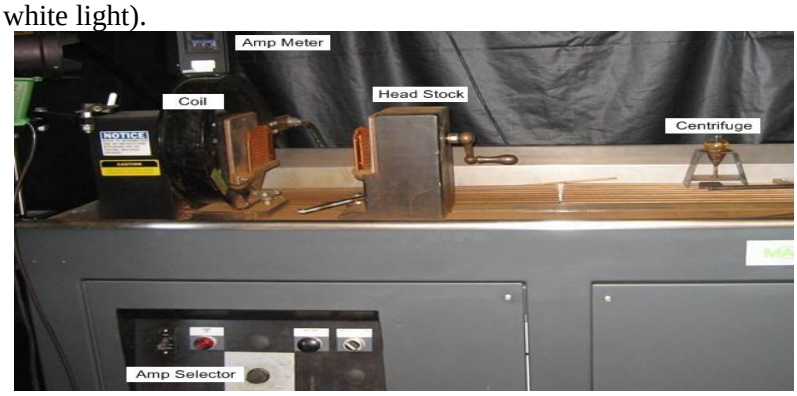


**Figure.2. Magnetic Particle Testing Machine**

## 3. TEST RESULTS

**Tensile test:**

**Table.1.Load vs strength**

| | Load | Yield Strength | Tensile Strength |
|---|---|---|---|
| 1g of graphene | 1720 | 217 | 305 |
| 2g of graphene | 1740 | 198 | 254 |
| Kevlar | 1650 | 159 | 200 |
| Carbon fiber | 2450 | 151 | 249 |
| Resin and hardener | 1160 | 232 | 270 |

**Non Destructive Testing:**

**Table.2.Visibility and cracks**

| | Weight (grams) | Visibility check | Crack test |
|---|---|---|---|
| 1g of graphene | 104.5 | Visibility is good | Cracks was formed only on the composite material it did not allow to crack the aluminum plate |
| 2g of graphene | 104.5 | Visibility is good | Cracks was formed only on the composite material it did not allow to crack the aluminum plate |
| Kevlar | 121 | Visibility is poor | Cracks was formed and aluminum was damaged |
| Carbon fiber | 125.5 | Visibility is poor | Cracks was formed and aluminum was damaged |
| Resin and hardener | 96.5 | Not visible | Cracks was formed and aluminum plate was damaged |

**Yield Strength and Tensile Strength:**

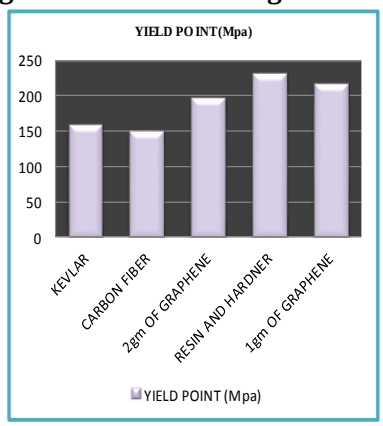


**Figure.3. Data Comparing Yield points of various test specimen**

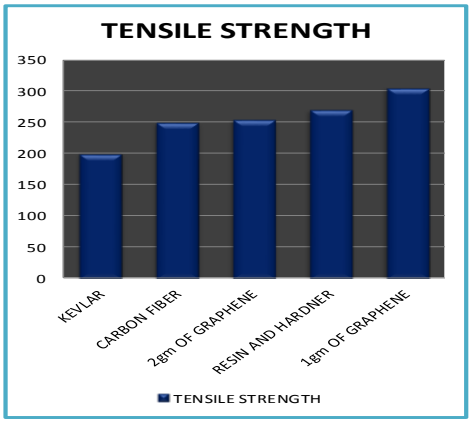


**Figure.4. Data comparing Tensile Strength of test specimens**

## 4. CONCLUSION

This project gives an in-depth knowledge of composites materials properties including "Graphene". Based on the testing carried out in this project for composite materials, it has been proved that "Graphene" material has excellent visibility which can be used for NDT testing for checking the material by applying "Graphene". It has been prove that it is an excellent protective layer for aluminum because of its high tensile strength. Overall goal is to protect the aircraft by getting damaged by bad weather conditions and to protect from dent. It is prove that Graphene can improve the material used in the aircraft, aerospace industry, automobile industry etc The material "Graphene", based on the testing conducted has proved that it can be used for future aircraft, space vehicles, bullet and mobile coating for better improvement on dent/damage resistance. This material can also be used for NDT testing over the material for testing purposes.

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