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Carbon Fiber Composites for Camshaft Material

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Abstract - Carbon Fiber is a lightweight, strong material, made out of carbon filaments, called precursors, which also has enhancing physical properties such as, high coefficient of heat transfer, electric conductvity etc. Carbon Fibre holds the way for extreme advnces in science because of it's dynamic stiffness inspite of being lightweight. Carbon Fiber, reinforced with a polymer or a metal matrix, forms a composite that acquires a superlative mixture of both the qualities of the constituent material. Researches conduted showed the way of numerous materials to be made into a carbon fibre composite. Some are already being utilised in engineering practices. The automobile and aviation industry finds much advantages in using carbon fiber composites, which results in production of lightweight automobile or aviation parts. Carbon Fiber holds a large significance in the modern world due to it's versatility and clean origin. Our research is based on finding a suitable metal matrix for a CF-MMC fabrication that could serve as engine part, in this case, Camshaft, possiby. We modelled a general automobile camshaft and assigned Aluminium graded 2024 to the imported model in ANSYS.

***Key Words*: Precursor, Carbon Fiber, Camshaft Material, Metal Matrix composite, Al2024**

1. INTRODUCTION

The introduction of carbon fiber to civilisation was made in late 1800s with the likes of Thomas Alva Edison developing baked threads of carbon to use as the heating filaments in incandescent bulbs. Carbon filament is produced from a polymer such as Polyacrylonitrile (PAN), rayon, or petroleum pitch, known as a precursor. For synthetic polymers such as PAN or rayon, the precursor is first spun into filament yarns, using chemical and mechanical processes to initially align the polymer atoms in a way to enhance the final physical properties of the completed carbon fiber. After drawing or spinning, the polymer filament yarns are then heated to drive off non-carbon atoms (carbonization), producing the final carbon fiber. Various manufacturers use the process sequence of Stabilizing, Carbonizing, Treating the surface and Sizing, to manufacture carbon fiber sheets or bundles. The atomic structure of carbon fiber is similar to graphite, to which it owes the brittleness. The ability to integrate itself with other metals, ceramics and composites give carbon fiber a greater edge due to the final properties of a fiber reinforced composite or metal alloy inherits properties that are characteristic to the constituent materials.

2. LITERATURE REVIEW & PROBLEM IDENTIFICATION

2.1 Literature Review

A Hong Kong University of Science and Technology (HKUST) research team led by Prof Yui-bun Chan from the Department of Civil and Environmental Engineering, with support from leading global aluminium producer UC RUSAL, has discovered a new aluminium composite. This new material is stronger than existing aluminium, cheaper and lighter than steel, and can also be used with insulation panels designed to produce a building envelope system that is safer, cheaper, more energy-efficient and easier to mount.

Fiber reinforced aluminium can be used for a wide range of applications primarily in construction as an alternative to steel and cement, and also in electronic products, automobiles, aircrafts, building materials, thus it has the potential to significantly increase aluminium's global applications. Scientists have long looked for a way to merge carbon fiber with aluminium. Prof. Chan's research team had managed to change the composition of carbon fiber by using nano technology, which allowed it to perfectly integrate with other substances like aluminium.

A carbon-titanium composite, named Carbotanium has been invented by Modena Design, which is the carbon-composite manufacturing and consulting ancillary of the Italian motor giant Pagani.

It is a combination of beta titanium alloy with carbon composites, having a matched yield strength and moduli of elasticity ratio. When the combination is adhesively bonded, both parts will reach maximum yield strength and fail at a similar amount of total strain. The titanium and carbon composites are combined by first abrading the titanium to be bonded, coating the titanium with platinum, aging the titanium, spraying primer on the coated titanium, applying adhesive to the primer side of the titanium and then applying the carbon to the adhesive. This allows the carbon composite to bond securely to the titanium. This composite uses the best properties of each component, the combination having a better set of properties than either part, the material being both strong and light. Pagani has applied this weave on their latter extra strong and lightweight supercars, the Zonda R and Huayra.

2.2 Problem Identification

With these many advantages, the problem lies in the price of the created composites, resulting due to the expensive

procedures involved in the production of carbon fiber itself. This gives rise to a decrease in availability enough to not let the efficiency of performance of machine increase. Magnesium based MMCs has drawbacks, because of magnesium's low thermal conductivity, which results in the operating parts running at a higher temperature than general cast aluminium alloys. Although, steps have been taken by certain manufacturers to produce low cost carbon fiber, for example, ORNL is presently leading a major initiative to develop disruptive technologies for producing low cost carbon fiber, focusing on areas like

(i) alternative precursors,

(ii) advanced, energy efficient processes, and

(iii) scaling for technology transition

(iv) alternative materials to reinforce with C-fiber

3. IMPLEMENTATION

A Working camshaft model was modeled in CATIA and then imported to ANSYS for further tests and analysis.

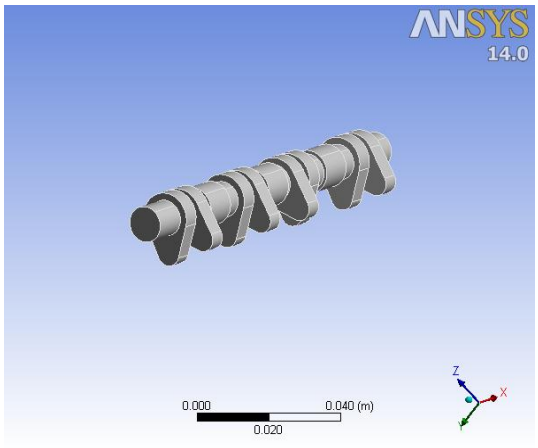

Fig 1 Camshaft Model

Properties of Metal Matrix used:-

Aluminium(Grade 2024) was selected for our carbon fiber composite using metal matrix in ANSYS. This Aluminium alloy has high strength, excellent strength and fatigue resistance and good strength to weight ratio.

Constituent alloy materials: Cu-3.8/4.9 ; Si-0.50(max) ; Fe-.50(max) ; Mn-0.30/0.90(max) ; Mg-1.20/1.80(max) ; Zn-0.25 ; Cr-0.10(max) ; Ti-0.15(max) ; other-0.15(max) ; Al-remainder. The ranges shown are for 0.750" size and under.

Typical Mechanical Properties(Minimum and Representative):-

Tensile Strength (PSI) 68000

Yield Point (PSI) 47000

Brinell Hardness 120

Material Data:-

Carbon Composite Al 2024

Density	1600 kg m^-3			
Temperature C	Young's Modulus Pa	Poisson's Ratio	Bulk Modulus Pa	Shear Modulus Pa
	7.2e+010	0.44	2.e+011	2.5e+010
Tensile Ultimate Strength Pa				
4.6e+008				
Compressive Ultimate Strength Pa				
5.7e+008				

The ANSYS results are as follows:-

TABLE 1 Results

Object Name	*Total Deformation*	*Strain Energy*	*Maximum Principal Stress*	*Minimum Principal Stress*	*Stress Intensity*
State	Solved				
Scope					
Scoping Method	Geometry Selection				
Geometry	All Bodies				
Definition					
Type	Total Deformation	Strain Energy	Maximum Principal Stress	Minimum Principal Stress	Stress Intensity
By	Time				

Display Time	Last				
Calculate Time History	Yes				
Identifier					
Suppressed	No				
Results					
Minimum	0. m	2.8663e-007 J	-2.4347e+007 Pa	-1.5274e+009 Pa	1.6483e+006 Pa
Maximum	1.8529e-003 m	0.61566 J	1.5132e+009 Pa	2.0122e+007 Pa	3.0211e+009 Pa
Information					
Time	1. s				
Load Step	1				
Substep	1				
Iteration Number	1				
Integration Point Results					
Display Option		Averaged			

3. RESULTS & CONCLUSIONS

On careful examination of the results of the analysis in ANSYS on our model designed in CATIA, we took notes that showed us that the material selected for the sample model in ANSYS, that is Carbon Composite Al2024 is theoretically feasible in automobile application as the fracture limits are well contained. Difficulty may arise while implementing in heavier work models.

We conclude that we successfully researched on a substitute metal matrix composite(Al2024) to be fabricated into a Carbon Fiber Composite.

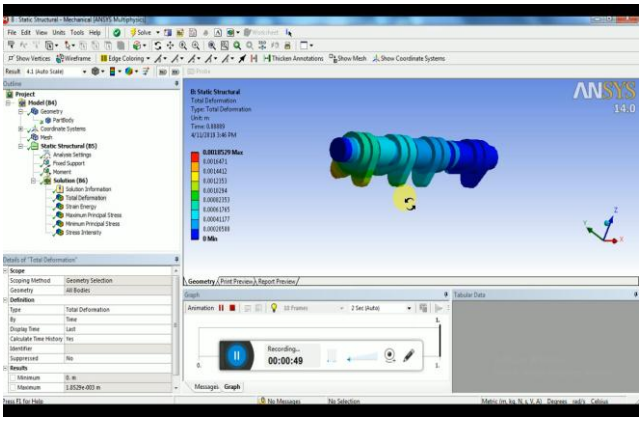

Fig 2 ANSYS work bench

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