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DEVELOPMENT OF CFRP COMPOSITES USING CARBON AND BASALT

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Abstract:

In recent times, increase in the use of eco-friendly, natural fibers as reinforcement for the fabrication of lightweight, low cost polymer composites can be seen globally. One such material of interest currently being extensively used is **Basalt fiber**, which is cost-effective and offers exceptional properties .The prominent advantages of these composites include high specific mechanical,physical and chemical properties, biodegradability, and non-abrasive qualities. **Carbon fiber** has the properties of high strength, high modulus, high temperature resistance, corrosion resistance, fatigue and creep resistance, electrical conductivity, and thermal conductivity. It is mainly used for the preparation of composite materials. CFRP Means **Carbon fiber reinforced polymer** (CFRP) is one of the composite materials which is used in both repairing and strengthening of reinforced concrete structures. In this project ,we would like to prepare a carbon basalt composite to understand the mechanical, thermal and chemical resistant properties achieved for applications in medical, aerospace and automotive industries.

NOMENCLATURE

- Ultimate Load KN
- Ultimate Tensile Strength .
- Elongation %
- Yield Load KN
- Yield Stress MPa

1.Introduction:

Composites are a group of materials that mainly constitutes metals, ceramics, and/or polymers in order to improve the composite properties. Usually, some stiffer, stronger materials are used as reinforcing agents in the composite matrix to enhance the mechanical and thermal behavior of the composite materials. Carbon fibers are the major load-bearing components in most of the composites.

Carbon fiber composites have always been regarded as the materials that can challenge steel in high structural applications. Polymers reinforced with carbon fiber are advanced composite materials, and they are utilized in a broad range of applications, such as aerospace and automotive industries and in sports equipment. Epoxy is the most commonly used polymer matrix with carbon fibers. In addition, polyester, polysulfone, polyimide, and thermoplastic resins are also used. When the carbon fibers are bound with a plastic polymer resin, it creates a composite material that is extremely strong, with high modulus, durable, low cost, and lightweight,

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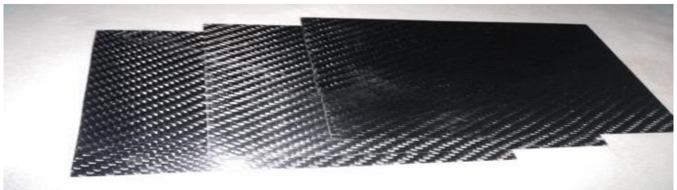
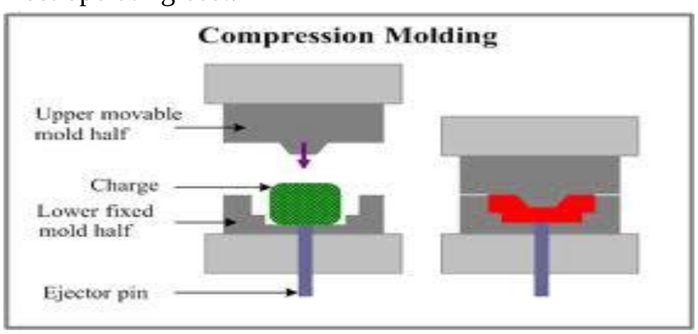
and can be found in many forms, including fabrics, tubes, and tows. Due to the superior nature of carbon fibers, their applications have been expanded to the construction industry, which uses carbon fibers to reinforce concrete.



Carbon fiber composites can have very great thermal conductivities, due to the incorporation of highly graphitic fibers. Therefore, composites reinforced with carbon fiber are also preferred in electronic systems, as a way of enhancing the removal of unwanted heat away from the electronic machines. This chapter focuses on carbon fiber reinforced composites and its various applications

Composites have been widely used across industries like aerospace, wind energy, automotive, industrial, marine, oil and gas. Advanced carbon fiber composites are comparatively more expensive than metals. The choice of composites is a tradeoff between cost and performance. As a result, carbon composites have made their impact in high performance vehicles, such as, jet fighters, spacecraft, racing cars, racing yachts and exotic sports cars. The global composites materials market is about $28Bn in 2014 and is growing at 15- 20% per year. This market size will further grow provided the cost of composites is reduced. The cost considered is primarily the composite manufacturing cost.

However, for correct assessment entire life cycle cost need to be considered including maintenance and operation. Composites provide a cost benefit particularly in respect of operation and maintenance which form a sizable percentage of direct operating cost.



A typical cost comparison between various materials is shown in Figure 1 and Figure 2 presents the worldwide market estimates for carbon fiber. Although, the cost of carbon fibers is high,

the market for carbon fiber in non-aerospace structures is increasing at a rapid rate as shown in Figure 3

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Figure 1. Cost Comparison of Materials

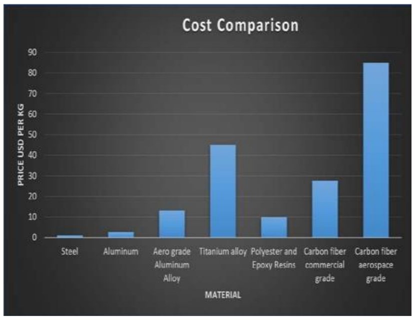


Figure 2. Global Consumption Carbon Fiber

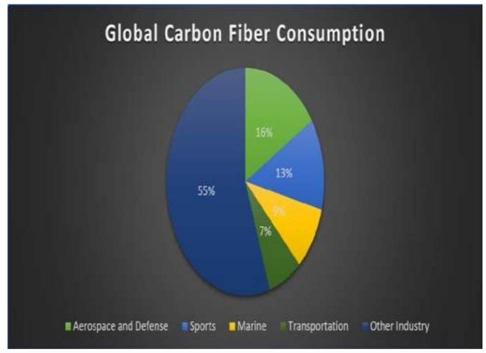
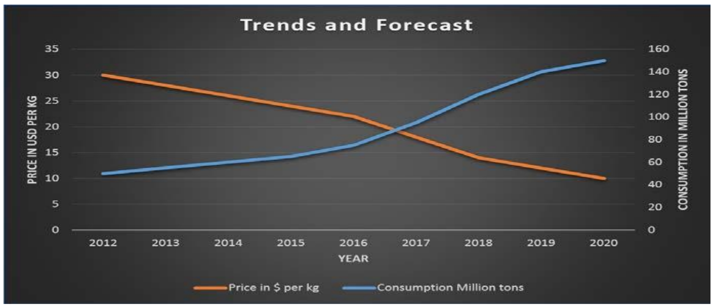


Figure 3. Trends and Forecast of Carbon fiber



EXPERIMENTAL WORK:

Material Selection:

Carbon fibers or carbon fibres are fibers about 5–10 micrometres in diameter and composed mostly of carbon atoms. Basalt fiber is a relative newcomer to fiber reinforced polymers (FRPs) and structural composites. It has a similar chemical composition as glass fiber but has better strength characteristics. Epoxy resin is a type of resin that possesses tough mechanical properties, good chemical resistance, and high adhesive strength, which makes it highly useful for various applications

Chemical Components	Percentage by Mass
SiO_2	51.6 - 59.3
Al_2O_3	14.6 - 18.3
CaO	5.9 - 9.4
MgO	3.0 - 5.3
$Na_2O + K_2O$	3.6 - 5.2

Comparative technical index betweenbasalt fibers & the other fibers					
Properties	ContinuousBasalt	E-Glass	S-Glass	Carbon	Aramid
Density(g/cm³)	2.63 - 2.8	2.54 -2.57	2.54	1.78	1.45

Tensile Strength (MPa)	4100 - 4840	3100 - 3800	4020 - 4650	3500 - 6000	2900 - 3400

2.Methodology:

Hand layup process

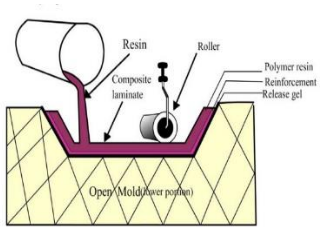
Hand lay-up technique is the simplest method of composite processing. The infrastructural requirement for this method is also minimal. The processing steps are quite simple.First of all, a release gel is sprayed on the mold surface to avoid the sticking of polymer to the surface.Reinforcement in the form of woven mats or chopped strand mats are cut as per the mold size and placed at the surface of mold after.Then thermosetting polymer in liquid form is mixed thoroughly in suitable proportion with a prescribed hardner (curing agent) and poured onto the surface of mat already placed in the mold.

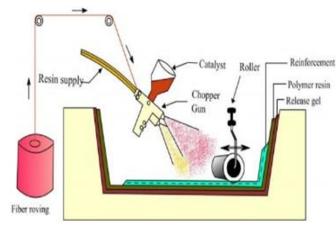
Spray – up Process

The spray lay-up technique can be said to be an extension of the hand lay-up method. In this technique, a spray gun is used to spray pressurized resin and reinforcement which is in the form of chopped fibers.Generally, glass roving is used as a reinforcement which passes through spray gun where it is chopped with a chopper gun.Matrix material reinforcement may be sprayed simultaneously or separately one after one.

Compression Moulding Process

Compression moulding is one of several moulding processes. It is the use of compression (force) and heat to shape a raw material e.g. hydraulic and pneumatic seals by using a metal mould. The raw material is heated in the mould until pliable while the mould is closed for a specified period. Upon removal it is quite common that the moulded product to contain excess materials, normally called flashing, which has extruded while being heated and compressed in the mould.





RESULTS AND DISCUSSION

Tensile Test Reports

- Ultimate Load KN : 36.000

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- Ultimate Tensile Strength Mpa : 631.579 .
- Elongation % : 3.800
- Yield Load KN : 31.740
- Yield Stress MPa : 556.82
- **Flexural Test Results**
- Ultimate load N : 892
- Flexural strength N/sq.mm : 487.91

Performance Evaluation

PROPERTY	CFRP CARBON BASALT COMPOSITE	STAINLESS STEEL 316
1.Tensile strength(Mpa)	631.579	515
2.Elongation (% in 50mm)	3.800	40
3.Hardness	94.67 (Shore D)	90(HRB-Rockwell)
4.Yield Stress(Mpa)	556.842	290

CONCLUSIONS

Different reinforcing fibers and their composites were tested under thermal and mechanical load. Tensile tests on rovings after exposition to high temperatures between 100 and 600 °C showed that basalt fibers had higher initial strength at low temperatures than E-glass fibers. Yet, softening was more severe for basalt fibers and over 300 °C tensile strength of basalt fibers was below of that of glass fibers. SEM showed changed fracture surfaces at high temperatures for basalt fibers, but not for glass fibers. This was assumed to originate from beginning crystallization in the basalt fibers, which was shown via polarization microscopy. Tensile strength of carbon fibers remained constant until about 300 °C and then decreased rapidly until 500 °C. A temperature of 600 °C led to oxidation and hence decomposition of carbon fibers. Tensile modulus remained constant for all fiber materials at all temperatures. Heat treatment and tensile strength measurement of unidirectional composite plates showed similar results. Again basalt composites had higher initial strength than glass composites, yet softened more severely, so that at high temperatures glass composites had higher residual strength. In conclusion it has to be stated that in contrast to former view basalt fibers and basalt-epoxy composites seem to have lower thermal resistance than glass fibers and glass-epoxy composites. Compared to carbon fibers basalt and glass fibers withstand higher maximum temperatures without decomposition, which can be considered favorable for use for composite pressure vessels

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