International Journal of Engineering Science Invention Research & Development; Vol. I Issue X April 2015
www.ijesird.com e-ISSN: 2349-6185

SYNTHESIS AND CHARACTERIZATION OF C/C COMPOSITES

Dr. Padmayya S Naik[1], Dr. A. O. Surendranathan[2] and Dr. Ravishankar k[3].
[1]Professor, Dept. of Mechanical Engineering, AITM, Bhatkal , [2]Professor and Head, [3]Assistant Professor, Dept. of Metallurgical and Material Science Engineering, NITK, Surathkal
[1]padmayyanaikshaniyara@yahoo.com , [2]surendranathana@gmail.com, [3]ravisankar787@gmail.com

Abstract: **Carbon-carbon composites are structures in which both the matrix and reinforcement are carbon. They offer many advantages in high temperature applications over composites fabricated with other matrix materials. The unique high temperature mechanical properties retention of C-C Composites (in excess of 2500 °C) and their low density (1.6 – 2. gm/cc) make them useful at high temperatures (i. e above 1350 °C in some cases and above 1700 °C for short-time, limited use application). For continuously used reinforced C-C composites, it is the mechanical properties of the carbon graphite fibers that dominate the C-C composite properties, and it is the high temperature capability of the carbon matrix that allows one to take advantage of the fiber properties at elevated temperatures, where most metal matrices had melted or polymer matrices have decomposed or melted. Hence we have synthesized conventional C/C composites and their properties were measured, showing good thermal stability and mechanical strength. From results it is very much clear that as the fiber percentage increases the material properties also increasing.**

1. INTRODUCTION

1.1 Carbon-Carbon composites

Carbon/Carbon (C/C) composites are composed of carbon or graphite fiber reinforcements in carbon or graphite matrices. They maintain high strength and low co-efficient of thermal expansion at temperatures above 2000 °C (3600 °F), and exhibit excellent thermal shock resistance. They also have superior toughness, excellent thermal and electrical conductivity, and resistance to corrosion and abrasion [1, 2]. In spite of this outstanding combination of properties, high cost has limited their applications primarily to aerospace and defense. However, new processing method involving performed yarns has been developed by the Across Company, Japan and Padmayya et.al. which is said to considerably reduce both cost and manufacturing time.

Conventional production methods of manufacturing C/C composites include CVD (Chemical Vapor Deposition) and a technology in which a thermosetting resin binder is carbonized. In the CVD method, a preform of carbon fibers having a specified shape is heated in a furnace to a high temperature, while a hydro-carbon gas is fed to the furnace. The gas is thermally cracked to form carbon, which then deposits uniformly on the fiber surfaces. In the other process, yarns or woven/nonwoven fabrics of carbon fibers are shaped into various structural shapes, with the use of a thermosetting binder such as phenolic or epoxy resin. The structure is subsequently heated in an inert gas atmosphere to carbonize the resin. These conventional techniques have reportedly encountered problems because the resulting C/C composites lack uniformity in properties such as bending strength and density [3, 4, and 5]. The processes are also complicated and time consuming.

The patented preformed yarn method involves producing yarn consisting of a bundle of carbon fibers in a matrix precursor of coke and pitch binder powders. The yarn is encased in a flexible thermoplastic sleeve to contain the powders during handling and subsequent processing. This simplified manufacturing process ensures better penetration of the binder into the carbon fiber bundle, there by resulting in higher strength than conventional C/C composites. Furthermore, the matrix powders are often derived from the residue of petroleum processing, which can have beneficial environmental effects. The preformed yarn may be woven into sheet or chopped to fill a mold, and is then hot pressed to form the composite product. Since the reinforcing fibers are homogeneously dispersed in the matrix, properties of the resulting composite are quite uniform. The preformed yarns have excellent workability and processability [8,9].

The major uses and system employing c-c composites are in the area of military and aerospace requirements dominate high performance applications, where structural and thermal properties are of crucial importance. The largest volume application, to commercial aircraft brakes, doesn't require high performance; this is also true of the applications to furnace insulation material. For these applications relatively inexpensive fiber components, such as chopped or discontinuous fibers, are adequate [11, 13].

1.2 Typical Characteristics of C-C Composites [12,10]

- Light weight and low density.
- High strength and stiffness.
- Low thermal expansion (thermal expansion coefficient is low).
- High thermal conductivity, decreasing with increase in temperature.
- High thermal shock resistance.
- High fracture and creep resistance.
- Pseudo plastic behavior.
- Good fatigue resistance.
- Corrosion resistance.

2. EXPERIMENTAL PROCEDURE

2.1 Synthesis of Conventional C/C Composites

In the preparation of carbon-carbon composites, the Carbon fiber as a reinforcement which PAN based fiber were used, Carbon Powder, Epoxy as a resin and DETA (Di-Ethyl tri amine) act as a catalyst. These constituents are mixed with required proportions and hot pressed at 600 °C at a load of 10 tones. The hot pressed composites subjected to heat treatment at 2500 °C under inert atmosphere giving 5-10 pitch cycles were given in order to get at least 1.4 -1.6 g/cc densities for different percentage carbon fiber samples . The table 2.1 shows percentage of carbon fibers and other compositions were used for C/C composites preparation.

Table 2.1 shows the percentage of carbon fiber and other compositions

Sl. No.	Carbon fibers in %	Carbon black in %	Epoxy resin in %	DETA in ml
1	30	5	65	10
2	40	5	55	10
3	50	5	45	10

3. RESULTS AND DISCUSSION

Carbon fiber is a brittle material. It is known about the carbon that, as the carbon component increases in a particular structural component the material gains brittle property. The previous fact of Material Science tells that, if the brittleness of the material increases the hardness also increases. From the table 3.1, shows that the increase in composition of carbon fiber increases the hardness property of the material this can also observed from the figure 3.1.

Table 3.1 Effect of Hardness, compression strength, MOR, and Densities on the various carbon fiber percentage reinforced C/C composites

Sl. No.	Fiber %	Brinell Hardness Number (BHN)	Compression strength (MPa)	Modulus of Rupture (Mpa)	Density (gm/cc)
1.	30	37.89	15.5	32	1.42
2.	40	43.81	18.5	34	1.47
3.	50	49.56	22.05	36	1.53

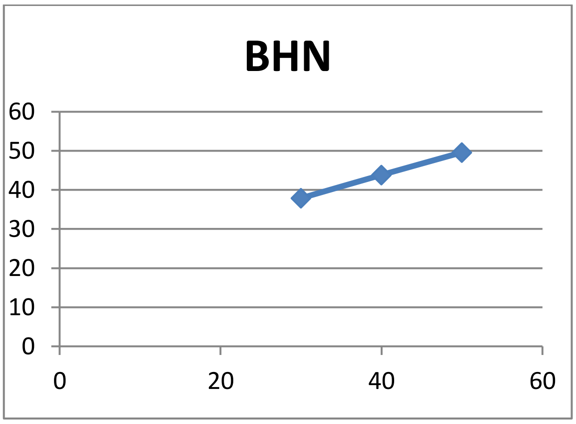

Fig.3.1 Graph showing Brinell Hardness Number v/s Percentage fiber Composition

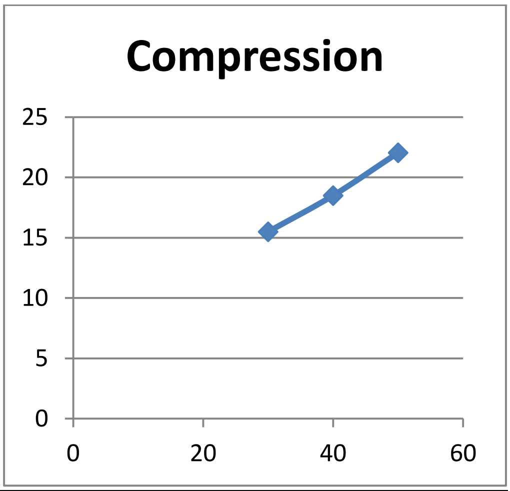

Fig.3.2 Graph showing Compressive Strength v/s Percentage fiber Composition.

As strength and hardness are both proportional to each other, the increase in the hardness increases the material ability to withstand at higher loads. from figure 3.2 it shows that the increase in the addition of carbon fiber increases the compressive strength, which obviously increases load carrying capacity of the materials.

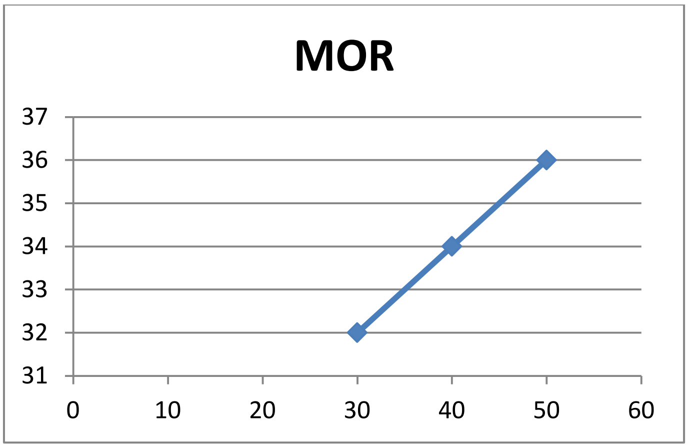

Fig.3.3 Graph showing Modulus of Rupture v/s Percentage fiber Composition.

The figure 3.3 shows the effect of modulus of rupture on the C-C material. From the figure it is understood that the increase in the composition of carbon fiber increases the modulus of rupture of the material.

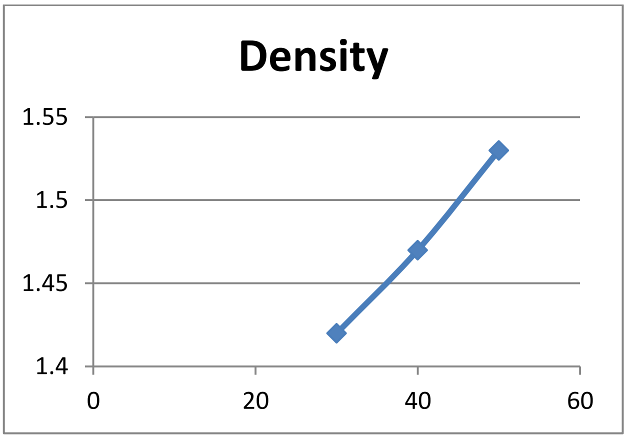

Fig.3.4 Graph showing Density v/s Percentage fiber Composition.

It is known that the density of carbon fiber is higher than the density of epoxy resin. The increase in the carbon fiber composition increases the density of the material, in turn its weight also increased. As shown in figure 3.4 indicates, the density curve raises with the addition of carbon fibers. Figure 3.5 shows the fiber distribution is uniform and more voids are present so, that some more impregnation cycles are required to get dense material.

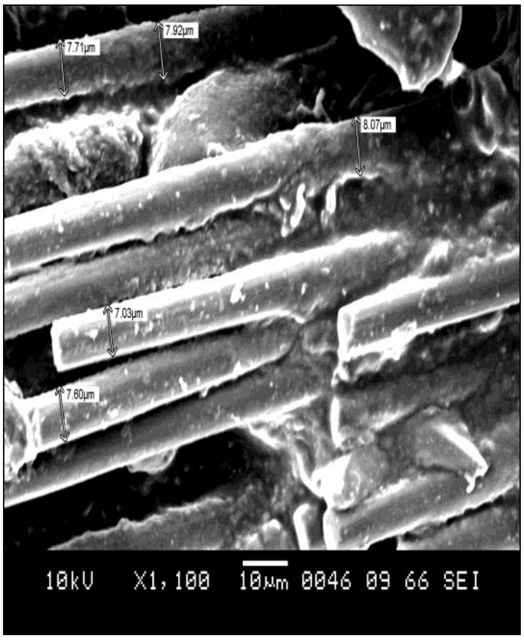

Fig.3.5 SEM analysis shows fiber distribution and bond between fibers

4. CONCLUSION

Advanced composites, particularly in Carbon-Carbon composites both matrix and reinforcement are carbon. These are relatively new composites and very expensive. These possess very high rigidity and elastic modulus, high compressive strength even up to 2000^{0}C. It also possesses high creep resistance and high fracture toughness. Because of its superior strength, weight, and stiffness properties they offer 25-30% savings in structural weight which is of a strategic importance in a military aircraft. They enable the designer to tailor-make the strength and stiffness in the desired direction as well as cut down drastically the number of parts to be assembled.

From the hardness, compression, and MOR test it is observed that when the carbon fiber content increases the material properties also increases. But, these properties are much less than the theoretical values because of low sintering temperature, and this is due to imperfect bond between the carbon fibers with carbon matrix, and is understood by observing the SEM photographs. It is also clear that carbon fiber distribution is perfect.

REFERENCES

1. Avtar Kaw. Mechanics of composite materials, CRC press New York, 1997.
2. B. Harris, "Engineering Composite Materials", The Institute of Metals, London 1986
3. F P Gerstle "Composites Encyclopedia of Polymer Science and Engineering, Wiley, New York 1991
4. Lubin "Handbook of Composite" 1991.
5. White. J. L, Sheaffer. P. M, "PAN Based Processing of Carbon-Carbon Composites", Carbon, Vol. 27, 1989, pp.697-707.
6. Jack W. Bary composite material hand book second edition vol 1.2, 10th edition pp 29 to 61.
7. Mel M. Schwartz composite material hand book second edition Mc Grow Hill Inc pp 1.1 to 2.74, 1992.
8. M. Rasheed Khan, Andrew. R. Barrone, "Carbon fibers Opportunities & Challenges-Advanced Materials & Processes". 2008.
9. K.K Chowla Composite material second edition Springer NewYork, 1998.
10. P.K.Jain and O.P.Bahl, "Mechanical Performance of Fiber Reinforced Composites", NPL New Delhi.
11. G. Savage "Corbon –Corbon Composites" Chapman & Hall , 1993.
12. High Performance C-C Composites" By Lalit M Monocha, Dept of Material Science, Sardar Patel University, Vallabh, Vidyanagar, India (Fitzer 1989 "Carbon fibers present state & future applications in carbon fiber filament & composite").
13. Mohammed Ibrahim, Mr. Padmayya S Naik and Dr. A O Surenderanathan.a project report on "short carbon fiber reinforced carbon- carbon composite for aerospace brake pad" World journal of engineering, 210-215, 2011.