Preparation and characterization of carbon fiber reinforced phenolic resin-based plastics composites (CFRP)

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ABSTRACT

CFRP composites prepared by the wet hand layup technique are important materials for the application in space/aviation industries. The important advantages of these composites are economical in price, and gives high carbon yields. In this paper, non-destructive evaluation technique has been used. The change of density and specially the porosity of the composites were analyzed. The structural characteristics of the composites were characterized by Archimedes's method.

Keywords: CFRP composites; Characterization; Porosity

1. INTRODUCTION

CFRP composites are finding more and more use, and becoming more and more important for space/aviation industries, and general structural applications[1-4]. And the carbon yields allow the conversion of CFRP to different advanced composites such as ceramics matrix composites (CMC) [5-7]. These materials express different stiffness and rigidity with other composite materials[8-12]. Low porosity levels are required for ensuring the performance of composite parts.It has been observed that the inter laminar shear strength reduces by 7% per 1% of porosity [13, 14]. Schulte-Fischedick has clarified the stress state during the heat treatment at the above temperature of 500○C, the first cracks appeared at the fiber/matrix interface[15-19. For this reason, the current work is to obtain the structural characteristics of these materials.The density and porosity measurements are studied.

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2. Experimental

2.1 Materials

The 3K poly-acrylonitrile(PAN) based high strength fibers which is supplied by Toray Industries Inc., Japan were chosen. For the matrix materials, phenolic resins adopted in this study was FB resins which is supplied by Bengbu High-Temperature Resistant Resin Factory, China. The characteristics of the supplied materials are listed in Table 1.

Materials	Density (g/cm^3)	Tensile strength (MPa)	Tensile modulus (GPa)	Diameter (μm)
Carbon fiber	1.76	3530	230	7
FB resin	1.28	≥71	≥3.6	3-20

Table 1. Properties of carbon fiber and FB resin

2.2 Preparation of CFRP composites

CFRP composites were manufactured by wet hand layup technique[1-4] is shown in Fig. 1.

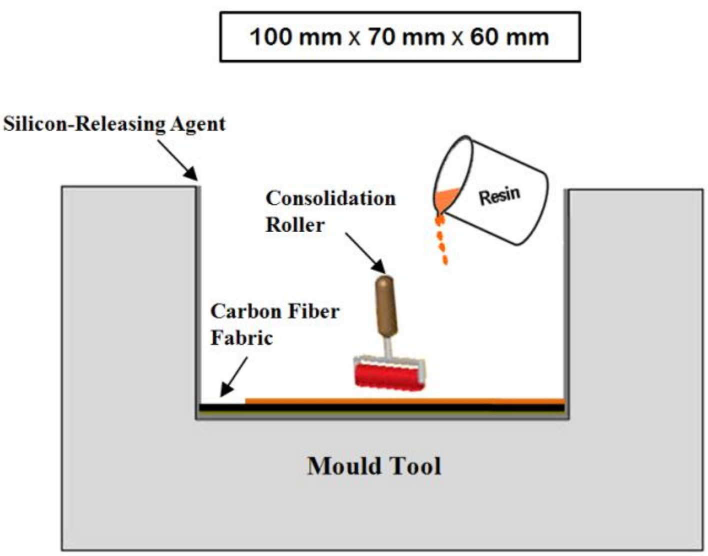

Fig.1.Schematic diagram of wet layup method.

A composite of thickness 4 to 4.5 mm was made by using 20 layers of the carbon fiber fabrics (0°/90°).The samples were cured at 150°C for 10 hours, and also post-cured at 240°C in ambient atmosphere for 10 hours. Schematic diagram of the fabrication technique for CFRP composites are shown in Fig. 2.

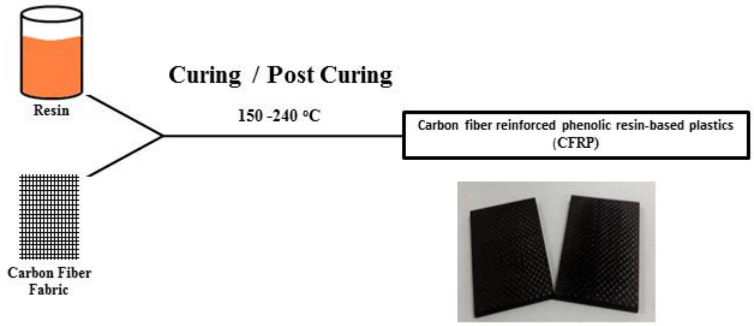

Fig. 2. Schematic diagram of the fabrication techniqueof CFRP composites.

2.3 Measurement

The analytical balance machine was used to measure the weight variation of the samples before and after yrolysis. The calculation for density (ρs) and porosity (Vν) of the samples using Archimedes principle were carried out in accordance with ASTM D792. The density and the porosity are given by Eqs. (1) and (2), respectively:

$$\rho_s = \frac{m\rho_0}{m_1 - m_2} \qquad (1)$$

$$V_\upsilon = 100 - \rho_s\left(\frac{\%m_{matrix}}{\rho_{matrix}} + \frac{\%m_{fibre}}{\rho_{fibre}}\right) \qquad (2)$$

Where ρ_s is the density, Vν is the porosity, % m matrix is the mass fraction of matrix, % m fiber is the mass fraction of fiber, ρ matrix is the density of matrix, ρ fiber is the density of fiber, ρ_0 is the density of water, m is the sample weight in the air, m1 is the sample weight measured after being immersed in the water for 24 hours and then wiped, and m^2 is the sample weight in distilled water.

3. Results and discussion

The density and the porosity values were calculated, and tabulated in Table 2.

Sample	*m* (g)	m_1 (g)	m_2 (g)	Density (g/cm³)	Porosity (%)
CFRP	166.8	208.6	95	1.47	3.95

Table 2. The density and porosity values of CFRP composites.

The Table 2 expresses the samples is fully dense, and can be expected to stand up in infiltration process [17, 20, 21]. Sampling variations for density values (Fig. 3)

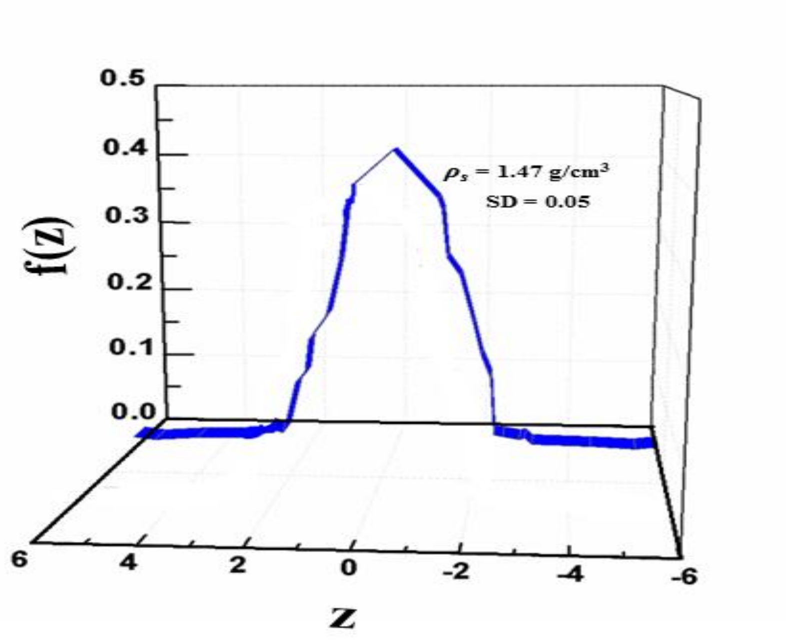

Fig.3. Sampling variations of actual density for CFRP.

were determined by Normal distribution equation [21]:

$$f\left(z = \frac{x-\rho_s}{SD}\right) = \frac{1}{SD\sqrt{2\pi}} e^{-\frac{z^2}{2}} \qquad (3)$$

where x is the density of a small block, ρ_s the mean of density samples, and SD is the standard deviation of density samples.

4. Conclusions

CFRP composites were prepared by wet hand layup technique. The density of the CFRP composites is 1.47g/cm^3, and the porosity is 3.95%. The major outcome of the above investigations was estabilishing the fact that these composites are potential candidates for new processing technologies with a wide range of technological applications.

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