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Effect of carbon powder surface treatment on carbon fiber reinforced PA composites

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Abstract

In this paper, carbon cloth woven in twill structure was adopted and a new kind of treatment method was used for carbon cloth, which is called carbon powder surface treatment. The detail method of carbon powder treatment is stated as following: phenol was dissolved in alcohol liquid and made into solution firstly, and then put the carbon cloth in the solution and let it soak, after that, the carbon cloth was taken out from the solution and put in an oven at a high temperature. The process above made phenol carbonized on carbon cloth. As a result, the surface morphology is slightly changed and in this way the bonding between the carbon fiber and the matrix was expected to be improved. Tensile test as well as bending test was conducted and the mechanical properties, such as tensile property and bending property were analyzed and discussed in this research. After that, observation on fracture section by scanning electronic microscope (SEM) and Dynamic mechanical analysis were also conducted in order to understand the fracture mechanism better.

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Keywords: carbon powder; polyamide; surface treatment; CFRP

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1. Introduction

In recent decades, carbon fiber has obtained increasing attention world widely as a kind of promising reinforcement in composite field. As the price of carbon fibers decreases these years [1], the application of carbon fiber as reinforcement in composites has broadened into many areas where high strength-to-weight ratio and rigidity are required, such as aerospace, automotive and public facilities, sports goods and construction industry [2, 3]. When manufactured into composites as carbon fiber reinforced plastic (CFRP), fiber can enhance the composite's mechanical properties for its higher strength than resin. The reinforcement will bring improvement to the CFRP in its strength and rigidity, which measured by stress and elastic modulus respectively.

However, the mechanical property of composites can be sufficiently improved only when fiber and resin have a good combination [4]. Thus, the bonding property between the reinforcement and the matrix is playing a very important role in determining the mechanical properties of composites. In particular, the bonding behavior in carbon fiber/matrix composites not only plays the role of transferring the load between fiber and matrix, but also affects the fracture behavior of the composites [5-6]. Force is transferred through the bonding system from the reinforcement to the matrix and therefore the bond characteristics influence the load transfer mechanism and then influence the mechanical properties of the composites. In order to achieve better composite mechanical properties, surface treatment might be a good approach to improve the bonding system between the fiber and the matrix [7]. Many conventional surface treatment methods have been attempted for carbon fiber [8], to improve the bonding property, including γ-ray radiation, electrochemically oxidation, plasma treatment, ozone (O_3), and so on [9-12]. In particularly, Hsieh et al. [13] has conduct oxygen treatment on activated carbon fabrics, and surface analysis showed that most of the oxygen functional groups created from the oxygen treatment. Wan et al. [14] conducted chemical treatment on CFRP. In their work, nitric acid treatment was found to improve the amount of oxygen-containing functional groups on carbon fiber surfaces and to increase the surface roughness because of the formation of longitudinal crevices. The treated composites exhibited stronger interface adhesion and better mechanical properties. There was a greater percentage of improvement in interfacial adhesion strength than in the mechanical properties. The strengthened interfaces and improved mechanical performance have been mainly attributed to the greater extent of the chemical reaction between the PLA matrix and the carbon fibers. Fischera et al. [15] adopted a UV laser (wavelength of 355 nm) and a CO_2 laser (wavelength of 10600 nm) as surface treatment and used to pre-treat specimens manufactured from 120°C curing epoxy. Lap-shear specimens have been pre-treated, bonded with a component epoxy film adhesive and tested. The result has shown that laser pre-treated specimens achieve the same bond strength as references prepared by manual abrading. Furthermore, the mechanisms of interaction between laser radiation and matrix material as well as fibers are improved. Lee et al. [16] studied the effects of plasma surface treatment of recycled carbon fiber on adhesion of the fiber to polymers after various treatment times. Hence, in this study, plasma processing was performed for 0.5 s or less. Surface functionalization was quantified by X-ray photoelectron spectroscopy. O/C increased from approximately 11% to 25%. The micro-droplet test of adhesion properties and the mechanical properties of CFRP were also investigated. Park et al. [17] conducted SEM and AFM experiments of thermal treatment and studied the effect on The interfacial properties by the thermal treatment temperature. And the results of better interfacial adhesion between the recycled fibers and the phenolic resin also showed that the interfacial properties of the CFRP chips were generally improved by the appropriate thermal treatment.

In this paper, carbon cloth woven in twill structure was adopted and a new kind of treatment method was used for carbon cloth, which is called carbon powder surface treatment. The detail method of carbon powder treatment is stated as following: phenol was dissolved in alcohol liquid and made into solution firstly, and then put the carbon cloth in the solution and let it soak, after that, the carbon cloth was taken out from the solution and put in an oven at a high temperature. The process above made phenol carbonized on carbon cloth. As a result, the surface morphology is slightly changed and in this way the bonding between the carbon fiber and the matrix was expected to be improved. Tensile test as well as bending test was conducted and the mechanical properties, such as tensile property and bending property were analyzed and discussed in this research. After that, observation on fracture section by scanning electronic microscope (SEM) and Dynamic mechanical analysis were also conducted in order to understand the fracture mechanism better.