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学　位　論　文　内　容　の　要　旨

博士の専攻分野の名称　　博士（工学）　　氏名　Md Tansirul Islam

学　位　論　文　題　名

Preparation of different types of carbon fiber reinforced polymer by using electrodeposition resin molding method

(電着樹脂成形法を用いた各種炭素繊維強化ポリマーの製造)

Composite material is one of the key components for the enormous development in aircraft and automobile industries. The amazing features of composite materials made it a suitable alternative of steels. Carbon fiber reinforced polymer (CFRP) is one of the most widely used composite materials because of having excellent properties such as good corrosion resistance, high strength and stiffness, low density, and a long fatigue life in the fiber direction. The growing interest of CFRP has led many researchers to improve the manufacturing methods of CFRP. This thesis presents a comprehensive study on the production and characterization of advanced carbon fiber reinforced polymer (CFRP) composites using the innovative and scalable Electrodeposition Resin Molding (EDRM) technology. In this technique, an electro-activated deposition solution served as the anode and the carbon fiber served as the cathode. Epoxy was chosen as the electro-activated deposition solution. The primary objective was to explore the potential of EDRM not only as an alternative to conventional composite manufacturing methods, but also as a platform for developing different types of CFRPs with enhanced mechanical and dynamic properties.

The first phase of the research focused on optimizing key EDRM processing parameters, including current intensity, voltage, and thermal curing conditions on the static and dynamic properties of composites. As for the dynamic properties, vibration test of the specimen had been carried out to obtain the natural frequencies and damping of the composites. In regard of the static properties, four-point bending test and tensile test was applied on the specimen to derive the bending strength and young modulus of the composites. Additionally, the effect of the heat curing temperature and period on the composite properties also investigated. Two different fiber orientation was used to prepare the preform. One was only plain weave and another was having TFP layers on top of the plain weave layers which was prepared by using a sewing machine called Tailored Fiber Placement (TFP) machine. Three different voltage condition (100V, 150V and 200V) and for each voltage condition, five different current conditions (0.50A, 0.75A, 1.00A, 1.25A and 1.50A) were applied. The effect of the voltage and current condition of EDRM was not that much significant on the vibrational characteristics of composites, while it had some effect on the bending strength. However, the heat curing temperature as well as the heat curing period had very noticeable effect on the bending strength of composites. Among the various conditions tested, composites cured at 230^oC and processed under 1.5 A current exhibited the highest flexural strength, highlighting the influence of heat and current on resin infiltration and interfacial bonding.

Three novel applications beyond conventional CFRP laminates were examined. Initially, cellulose

nanofiber (CNF) sheets were used as dielectric layers inside the laminate to create CFRP-based structural capacitors. Other dielectric materials such paper, tissue, plastic and jute fiber also used for insulation in order to compare their multifunctional performance with CNF. These composites' mechanical strength and detectable capacitance suggested that they would make good lightweight structural elements that store energy. Although the Young's modulus was somewhat compromised, it was discovered that the capacitance and bending characteristics of composites were significantly improved by the use of CNF as a dielectric. The bending strength of CFRP with CNF is around 6% more than that of CFRP without CNF. Additionally, using CNF into CFRP resulted in a maximum capacitance of 813 nF/m^2.

Next, the impact of curvilinear fiber architecture more especially, sine and parabola wave patterns on CFRP vibrational behavior was explored. Curved fiber routes considerably changed the dynamic response, according to modal analysis, and sine-shaped fibers offered the best damping and energy dissipation properties. The potential of fiber steering in adjusting composite vibration performance for dynamic applications is highlighted by these findings.

Finally, Nylon 6 hybrid composites were developed by embedding thermoplastic layers within the epoxy matrix. Toughness, bending strength, and impact resistance were all enhanced by this arrangement. The successful incorporation of Nylon 6 into the composite system and improved fiber-matrix adhesion were validated by SEM and Raman spectroscopy. All the results from the experimental testing showed that the carbon fiber/nylon 6/epoxy composite had outperformed carbon fiber/epoxy composites in all mechanical tests conducted. The bending strength of CFRP was increased almost double by adding nylon 6. Additionally, the CFRP including nylon 6 had consumed 38% higher impact energy than normal CFRP.

Overall, this study shows that EDRM provides a flexible platform for creating high-performance, tailored composite materials in addition to being a practical production method for CFRPs. In aerospace, automotive, and multifunctional engineering applications where weight reduction, structural efficiency, and functional integration are crucial, the results provide insightful information for future CFRP component design.