Preparation of a Carbon Fiber Reinforced Epoxy Composite and Increasing The Flight Performance for Radio Controlled Model Helicopters

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Abstract

Composite-material technologies have matured over the past 40 years to the point where high performance composites are being used to enhance the performance of nearly every new flight vehicle [1]. Carbon fibers have been used to replace metals used in composite materials because its performance-price is changing favorably [2]. They are also lighter and stronger than metals. This is the main reason why carbon fibers are used in composite materials. They also reduce fuel consumption and provide energy efficiency [2]. Furthermore, they have been used in many products, such as cars, airplanes, sporting goods, space vehicles and custom-designed products [2]. In this study, carbon fiber reinforced epoxy composite (CREC) was prepared and the flight performance of a radio controlled model helicopter with CREC chassis was evaluated. According to test flights it was observed that carbon fiber reinforced epoxy composites increase the flight performance of model helicopters.

Keywords:*Composites, carbon fiber, flight performance, radio controlled model helicopter*

1.Introduction

The materials needed to construct theoretrical models conceived by aircraft designers did not exist for many years [1]. Composite materials have allowed engineers to overcome difficulties and now they are frequently used in the aircraft industry. They are five times lighter and seven times stronger than aluminium. Therefore, they are important to the aviation industry. The most important benefit of composite materials is their weight, which plays a fundamental role in their selection. They provide additional advantages such as high strength, design flexibility, dimensional stability, high dielectric strength, corrosion resistance, light weight, simplicity of molding, surface treatment compatibility, high temperature resistance, transparency, high chemical resistance, vibration damping, acoustic conductivity and sound absorption. These factors have roles in reducing the operating costs of aircrafts in the long term, increasing fuel efficiency and performance [3,4,5].

A composite material is formed by combining two or more constituent materials with

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substantially different physical or chemical properties, resulting in better properties than either constituent can provide independently. But, unlike a metal alloy, the constituents do not dissolve into or blend with each other, they remain separate and distinct within the finished structure [6,7]. One constituent serves as a bonding matrix while the other serves as reinforcement, in the form of fibers within the matrix[1]. In principle, a base matrix is prepared in a mould under high temperature and pressure. Subsequently, an epoxy or resin is poured over the base material, and when the composite is cooled, a strong material is attained [3].

1.1.The manufacturing process

A common feature of all composite processes is the combination of a resin, a curing agent, and a reinforcing fiber. In general, heat and pressure are used to shape and cure the mixture into a finished part. The resin holds the fibers together and transfers the load to the fibers in the manufactured composite part. The curing agent (or hardener) acts as a catalyst in curing the resin into a hard plastic. The reinforcing fiber gives strength and other properties which are necessary for the composite.

The most common manufacturing process is prepregging. In this method, the resin and curing agent are impregnated into the reinforcing fiber. The prepreg must be reserved in a freezer until used in the manufacturing process. Cold storage is maintained to prevent premature chemical reaction. These prepreg materials are frequently preferred in the composite industry, especially in the aircraft and aerospace industries (Figure 1).

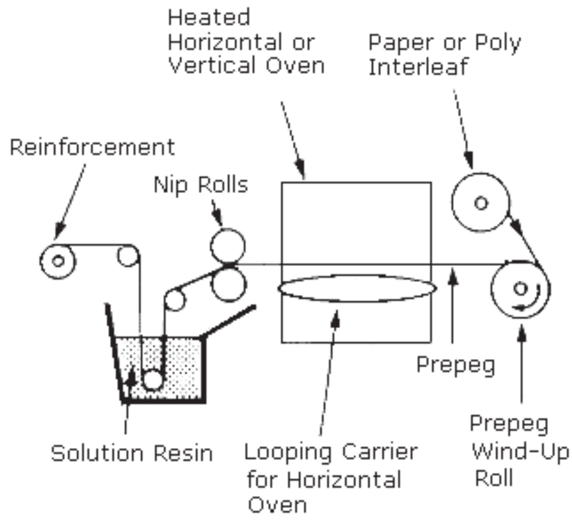

Figure 1. *In the prepregging process, a resin is applied to a reinfocement fiber. To saturate the fiber, it is dipped through the liquid resin or it is impregnated through heat and pressure.*

1.2.Polymer matrix composite resin systems

Thermoset resins are generally used in manufacturing composites. They require addition of a curing agent or hardener and impregnation on to a reinforcing material, followed by a curing step during the manufacturing process of the finished part.

The most common and important class of epoxy resins widely utilized in the industry is formed from reacting epichlorohydrin with bisphenol A. The curing agents or hardeners are fundamental ingredients of a composite sytem because they control the reaction rate and determine the performance features of the finished part. These compounds must include active sites on their molecules because they serve as catalysts.

1.3.Fiber Reinforcements

Fibers are added to the resin to give strength to the finished part. They are an integral part of the composite system; however they don't react with the resin. The most frequenly-used reinforcement materials are carbon fibers[8].

Carbon fiber is a very durable material which has a fibrous structure. The raw material of carbon fiber is acrylic. Carbon fiber is produced by the combination of nylon and tar [9]. This fiber is manufactured at furnace temperatures of 1000-2000°C. At these temperatures, the carbon atoms in the fibers are rearranged to provide the properties necessary for the finished fiber[8]. The carbon fiber manufacturing process comprises four chemical stages:

1)The Oxidation step, achieved by heating the fibers at lower temperatures in air (approximately 200-300°C), which allows the spun fibers to pick up oxygen molecules and separate from hydrogen.

2)In carbonization step carbon atoms are bonded in a crystalline structure, which is accomplished by heating the fibers to approximately 1000-3000°C.

3) Electric surface treatment helps prepare the fibers for bonding to resins by adding small amounts of oxygen and roughening the surface or electrically coating the fibers [10].

4) Coating, where a neutral finish protects the fibers from proximate treatments such as prepreg, is performed on fibers that are typically molded with epoxy resin to act as an interface between the fiber and resin [4].

Carbon fibers are manufactured by the controlled thermal treatment of organic precursors (polyacrylonitrile, pitch or rayon) in fibrous form [5]. Today, the polyacrylonitrile (PAN)-based carbon fiber is the most utilized precursor in the composite industry [8]. This white fiber is produced by extruding and processing an acrylonitrile-based polymer, which when integrated with plastic resins produces a carbon fiber composite prepreg for fabricating composite structures [11]. Polyacrylonitrile, a hard, rigid thermoplastic material that is resistive to numerous chemicals and solvents, is of low permeability to gases and slow-burning and is the key ingredient in high-performance parts used in aerospace applications [12]. Its features are key to obtaining the high tensile stiffness and tensile strength properties essential in defense and commercial aircraft applications [11].

2. Material and Method

In this study, CREC material was prepared. Test flights were carried out by using an aluminium alloy chassis and a CREC chassis and compared.

2.1. Materials

- Radio controlled model helicopter: x2; Align Corp.Ltd
- Motor: DJI.920 KV Brushless Motor
- Flight Control Board: DJI Naza. M V2 Main Controller
- Battery: 14.8 Volt 10.000 mah li-po
- CREC material: Shandong Evergreen Industries Ltd.
- 2024-t3 aluminium (Al) alloy: Zhongfu Industrial Henan Jiayuan Al Industry Co. Ltd.

2.2. Determination of weight and flight performance

The 2024-t3 aluminium alloy, which is used in construction of passenger aircraft (Figure 2), was cut and mounted onto the radio controlled model helicopter (Figure 3). The process was repeated for CREC material (Figure 4) on another radio controlled model helicopter.

Figure 2. *2024-t3 Aluminium alloy chassis.*

Figure 3. *Radio controlled model helicopter.*

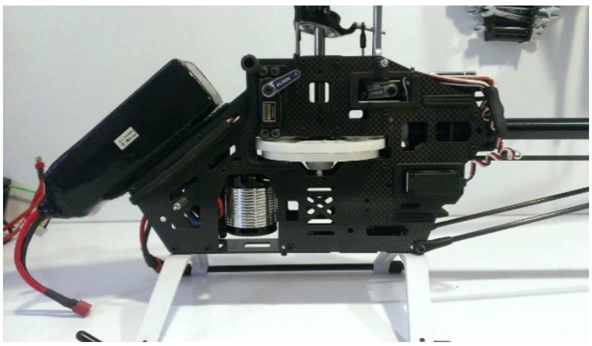

Figure 4. *Carbon fiber reinforced epoxy composite chassis.*

The weights of vehicles made with aluminium alloy chassis and carbon fiber reinforced epoxy composite chassis were measured and test flights for both vehicles were carried out. Test flights for both vehicles were repeated three times and their flight times were determined.

3.Results and Discussion

The weights and flight performances of radio controlled model helicopters were compared (Table 1)

Table 1. *The Comparison of CREC and Al Chassis*

	Aluminium alloy chassis	Carbon fiber reinforced epoxy composite chassis	Difference in percentage
Weight (kg)	2.33	1.9	18.45% ↓
Mean flight time (min)	13	17.3	33%↑

It was observed that the radio controlled model helicopter with CREC chassis was lighter and its flight performance was better than the model helicopter made of aluminium alloy.

4.Conclusion

In this study, it was determined that the flight performance of the radio controlled model helicopter was increased by using lightweight CREC material.

Carbon fiber composites have a great future ahead of them and it is a growing market. Composites are used for areas such as aerospace and aviation industry, weapons, rockets and other ammunition industries, urbanism, household appliances, automobiles, civil engineering, agriculture and construction equipments[4].

Carbon fiber composite materials are important to the aircraft industry because they provide a lighter weight and greater structural strength when compared to metal alloys. Usage of such materials will reduce fuel consumption, improve efficiency and reduce direct operating costs of aircrafts[3].

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