CARBON FIBER
THIN WALL MOLDING

FIELD OF INVENTION

The present invention relates to the field of over-molding of polymer material over carbon fiber using injection molding so as to create a thin wall over-molded polymer product. More particularly, the carbon fiber is available in the form of mat comprises of a certain number of carbon filaments per tow and is twilled weaved.

BACKGROUND OF THE INVENTION

Carbon fiber is light weight but has high strength to weight ratio. It is stiff, has good mechanical properties and is resistant to fatigue. This makes it ideal for high-performance applications such as aerospace, automotive and other structural part applications. However, its surface can be challenging to bond with other materials, and sometimes surface preparation is needed prior to such bonding.

Hence overmolding of the polymeric material over carbon fiber can help improve the durability and aesthetics of the carbon fiber material. Polymers can offer additional benefits like flexibility, impact resistance and corrosion protection. Different polymers can be selected to provide specific characteristics such as flexibility, chemical resistance, or thermal stability. During overmolding, the polymer is shot and cured to bond with the carbon fiber, forming a composite material. The composite material exhibits enhanced mechanical properties, including stiffness and tensile strength.

In terms of manufacturing techniques, the traditional methods of combining carbon fiber and resin involved labour-intensive processes and it is time consuming. It might even

have the possibility of uneven surfaces created. Some common approaches involved in the traditional methods include the following:

1. **Carbon fiber FRP (fiber reinforced polymer) layering using;**

   (a) Epoxy Resin: This is one of the most widely used methods to create a composite material by combining the carbon fiber filaments with a resin such as epoxy, vinyl ester or polyester resin. Epoxy is often preferred for its superior mechanical properties and better adhesion to carbon fibers. The surface of the carbon fiber is often treated to enhance adhesion. Carbon fiber sheets are laid on the substrate to be reinforced followed by applying a layer of epoxy resin. The resin is sent for curing so that it hardens to form a strong bond. The process is repeated layer by layer depending on the performance requirements, e.g. strength, weight, stiffness.

   (b) Vinyl Ester and Polyester Resins: These resins can also be used for bonding carbon fiber, particularly in applications requiring good chemical resistance.
2. **Thermoplastic Adhesives**: In this method, thermoplastic polymers are used. These can be heated to become pliable and then pressed against the carbon fiber, forming a bond upon cooling.
3. **Mechanical Fastening**: While not a chemical bond, mechanical methods like bolts, rivets, or screws can also be used to join carbon fiber components to polymers, providing a physical connection.
4. **Surface Treatment**: Surface treatments like plasma treatment can improve the bonding surface of the carbon fiber, enhancing adhesion with the polymer.

The present invention discloses a thin-wall molding process to overmold a polymer material onto carbon fiber. Thin wall molding of polymer over carbon fiber is a process

that combines the lightweight and high strength properties of carbon fiber with the versatility of polymers, allowing for improved functionality and versatility in a range of applications. Thin wall overmolding allows for more efficient high-volume production, reducing weight and material usage in the molded product as compared to traditional method which consumes more carbon fiber material, labour intensive, time consuming and the possibility of creating uneven surfaces. Hence the present invention makes it suitable for use in structural applications where weight savings and structural integrity are critical.

For the present invention, carbon fiber substrates are prepared in the mat form consisting of a certain number of carbon fiber filaments per tow that are specially weaved together. Depending on the design of the molded part, the carbon fiber mat can be cut into the desired size so that it can be fitted and positioned inside the mold cavity. Twill weave is chosen for the present invention as the carbon fiber filaments are closely and tightly packed and weaved together, which makes it difficult for the injected molten polymer to flow through.

Vertical Injection molding is being utilised, although horizontal injection molding can also be applied depending on the design, shape and size of the molded part. Using the vertical injection molding machine, the vertical orientation helps facilitate filling and ensuring that it penetrates the carbon fibers to create a strong bond so that the polymer fully encapsulates the carbon fiber mat. Also, the size of the molded part detemines how thin the wall thickness should be.

To describe the process, firstly, the carbon fiber mat is to be cut into the desired size and positioned within the mold cavity. Next, the mold is closed and heated up to the desired

set temperature based on the molding parameters set out for the polymer and the carbon fiber. The mold is heated to ensure that there is proper polymer flow during injection and to aid in the bonding of the polymer to the carbon fiber mat. This is then followed by the polymer injection stage whereby the molten polymer is injected into the mold cavity over the carbon fiber mat. Thus, this allows the carbon fiber mat to be overmolded by the polymer. After injection, the molten polymer is allowed to cool. The carbon fiber mat helps in heat dissipation, which can reduce cycle times. Once the polymer has cured and solidified together with the carbon fiber, the thin wall molded part is then ejected from the mold. The molded part will then be cut out using secondary processes such as in-mold cutting or external cutting using an external cutting jig followed by trimming of any excess carbon fibers on the edge of the finished over molded part in order to make it aesthetically pleasing.

In addition, the process disclosed in this present invention can also incorporate or embed electronics or sensors onto the molded end part, thus making the part “smart” such that it can communicate with the user depending on the application. The electronics or sensors can be placed together with the carbon fiber mat and then having it being over molded by polymer. Overmolding polymer over such electronic components can help to protect the electronic components against environmental factors such as moisture, dust and heat. With such embedded electronics used during the ovemolding of thin wall polymer over carbon fiber, it can be useful for product applications such as flying drones, automotive related applications, etc.

Therefore, to summarize, thin wall carbon fiber overmolding offers the following **key advantages** over traditional method:

1. Speed – thin wall carbon fiber overmolding is less labor intensive, faster and hence makes it suitable for high volume production as compared to traditional method of carbon fiber layering which is slower, time consuming and labor intensive;
2. Molded part quality – the present invention produces molded parts with quality and dimensions that can be controlled via injection molding as compared to traditional method that has the possibility of creating uneven and less precise surfaces.

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BRIEF DESCRIPTION OF THE DRAWINGS

The drawings attached here are to aid comprehension of the description of the invention here. The drawings are not to scale and they are to be used for merely illustrating the principles and concepts of the invention only.

To aid in comprehension of the invention, the drawings are separated into the various Figures as described below:

Figure 1 illustrates the carbon fiber mat before overmolding.

Figure 2A, 2B and **2C** illustrate the overmolded part after overmolding.

Figure 3A, 3B and **3C** illustrate the key stages during the overmolding process.

Reference numbers

1	Carbon Fiber Mat
2	Plastic Disc (underside)
3	Overmolded Plastic Disc
4	Metal insert
5	Mold cavity
6	Polymer injection stage
7	Embedded sensor

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT OF THE PRESENT INVENTION

In the following description, details are provided to describe the embodiment of the application. It shall be apparent to the person skilled in the art, however, that the embodiments may be practiced without such details.

The present invention here relates to the field of the field of over-molding of polymer material over carbon fiber using injection molding so as to create a thin polymer wall over-molded product.

Figure 1 illustrates the carbon fiber before overmolding. The carbon fiber mat **1** can be cut into the desired size with a certain dimension x and y as denoted in **Figure 1** so that it can be fitted and positioned inside the mold cavity **5** of the metal insert **4** in **Figure 3**. Next, **Figure 2a, 2b** and **2c** illustrate the embodiment of the present invention after overmolding. **Figure 2a** illustrates the bottom side of the plastic disc **2**, a result of the overmolded polymer shot to circular plastic disc with the carbon fiber which is now the top surface of the overmolded part denoted as **3**, as shown in **Figure 2b** and **2c.**

Figure 3A, 3B and **3C** illustrate the key stages during the overmolding process. For this present invention, a vertical injection molding machine will be illustrated with a metal insert **4** having a mold cavity **5** (both illustrated in **Figure 3A**) that is specially designed and fabricated for thin wall molding. The steps are as follow:

(a) Firstly, the carbon fiber mat **1** can be cut into the desired size with a certain dimension x and y as denoted in **Figure 1a** so that it can be fitted and positioned inside the mold cavity **5** of the metal insert **4** in **Figure 3A**.

(b) Next, heating up the mold to the desired set temperature as specified by the process parameters followed by

(c) closing of the injection mold; followed by

(d) injecting the polymer material (denoted as **6**) into the mold cavity **5** and onto the carbon fiber mat **1** as denoted in **Figure 3A**; followed by

(e) curing and cooling within the injection mold as denoted in **Figure 3B**; followed by

(f) ejection of the over molded thin-walled plastic disc part **3** from the mold as denoted in **Figure 3C**; wherein

(i) the over molded thin-walled plastic disc part **3** can be either subject to in-mold cut prior to ejection to the desired shape and dimensions or

(ii) using an external cutting jig to cut it out followed by trimming of any excess carbon fibers on the edge of the finished over molded thin-walled part in order to make it aesthetically pleasing.

In addition, electronic sensors (denoted as **7** in **Detailed View A** and **B** of **Figure 3**) can be embedded together with the carbon fiber mat **1**, followed by injecting the polymer material and having it over molded such that the electronics or sensors can be embedded or incorporated onto the molded thin wall end product. This will make the molded end product able to communicate with other product applications depending on the user application. Therefore, the present invention presented how the thin wall overmolding of polymer on carbon fiber will look like after it is being injected out.

While what has been described hereinabove is the preferred embodiment of the invention, those skilled in the art will understand that numerous modifications may be made without departing from the spirit and scope of the invention. The embodiments described herein are meant to be illustrative only and should not be taken as limiting the invention, which can be expressly set forth in the following claims.

CLAIMS

What is claimed is:

1. A **<u>method</u>** for thin wall over molding of polymer over carbon fiber via injection molding, whereby it comprises of the following:
   (a) preparing a carbon fiber mat which is twilled weave and is cut to size;
   (b) selecting a vertical injection molding machine with a mold cavity that is specially designed and fabricated for thin wall molding; followed by
   (c) placing the cut-up carbon fiber mat onto the mold cavity; followed by
   (d) heating up the mold to the desired set temperature as specified by the process parameters, followed by
   (e) closing of the injection mold; followed by
   (f) injecting the polymeric material into the mold cavity and onto the carbon fiber mat; followed by
   (g) curing and cooling of the over molded thin-walled part; followed by
   (h) part ejection from the mold; wherein
      (i) the molded thin-walled part can be either subject to in-mold cut prior to ejection to the desired shape and dimensions or
      (ii) using an external cutting jig to cut it out followed by trimming of any excess carbon fibers on the edge of the finished over molded thin-walled part in order to make it aesthetically pleasing.

2. A **<u>method</u>** of **claim 1** whereby
   (a) the electronics or sensors can be positioned or attached together with the carbon fiber mat and followed by

(b) injecting the polymeric material and having it over molded such that the electronics or sensors can be embedded or incorporated onto the molded thin wall end product part, wherein

(c) this will make the molded end product part able to communicate with other product applications depending on the user application.