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CARBON FIBERS: DEVELOPMENT AND MANUFACTURING PROCESSES INVOLVED- A REVIEW PAPER

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ABSTRACT

Metal-based structural materials have gradually been replaced by stronger, lighter and more durable composites made from carbon fiber. In the last decade, carbon-based composites have had a greater or greater durability due to their wide application in various fields such as aerospace, wind energy, automotive, etc. equal to that of steel and comparable to that of a plastic. This technology has enormous future potential due to its widespread use in high-performance applications and is expected to have a significant impact on industrial manufacturing. This review article attempts to examine the various manufacturing methods of carbon fiber manufacture and the various developments that have occurred to date, as well as their application and future.

Keywords: Carbon Fibers, Composite, Carbon Fiber Reinforced Polymer, CFRP.

I. INTRODUCTION

A carbon fiber can be a fibrous carbon material that has a micro graphite crystal structure made by fibrillation of acrylic, a documented textile material, and then a special heat treatment. Among them, PAN-based carbon fiber is one of the largest and most widely used productions in terms of quantity. Pitch-based carbon fiber manufacturers entered the market. As a result of relentless technological improvements and business expansion, Japanese carbon fiber manufacturers maintain their position as the global favorite for both quality and volume of carbon fiber production. or metal as a matrix. Carbon fibers are widely used for some kind of large-format applications with excellent mechanical properties (specific durability, specific modulus) and other properties thanks to low-density carbon material, low thermal expansion coefficient, heat resistance, chemical stability, self-lubrication Fiber composites are considered in many in recent years Sectors as a replacement for metal components, as fiber composite materials have a low specific density, high strength and rigidity, higher corrosion resistance and better fatigue behavior compared to conventional metals. Performance of these fiber reinforced composites under various load conditions; Axial, torsional and shock loads are critical to the design of structural components, and the mechanical properties of fiber-reinforced polymer composites depend on the fiber, matrix and the interface between them. of remarkable properties of the combination of carbon fibers and polymer matrix. The properties of these CFRPs can be improved by using various additives.

II. LITERATURE REVIEW

Carbon fiber

Carbon fiber is a high-performance fiber with long filaments that are approximately 5 to 8 μm in diameter. The manufacturing process includes pyrolysis and crystallization of the precursor above 2000 ° C. Carbon crystals are strung along the fiber and woven into a fabric., Polyacrylonitrile (PAN) precursors, pitch precursors are three types used in carbon fiber manufacturing process. The low initial bulk yield (25%) is the main disadvantage of rayon precursors. The fiber made from it is less uniform. The precursor to PAN is universally used for commercial carbon fiber manufacture. Approx. 50% of the initial fiber mass is obtained from this precursor. Carbon fiber reinforced polymer has a promising lifespan than aramid and glass fiber.

Carbon fiber reinforced polymer

The carbon fiber reinforced polymer composite is a heterogeneous substance formed by the combination of two or more materials, which materials retain their own properties, have anisotropic properties, and consist mainly of two fiber and matrix materials that are put together to provide the final product. It is mainly used carbon fiber, which adds to the need for strength and rigidity. And a polymer compound is used as the matrix, which gives the CFRP compound rigidity and environmental protection.

Manufacturing of carbon fiber and carbon fiber reinforced polymer

The PAN yarn is mixed with other ingredients and spun into fibers, which are then washed and stretched. The surface of the fibers is oxidized in order to improve the binding properties. Carbonization stabilized fibers are heated to very high temperatures in order to form strongly adherent carbon crystals. The fibers are chemically modified to stabilize the bond. The size fibers are coated and wound into bobbins which are loaded into spinning machines that twist the fibers into yarns of various sizes. Instead of woven fabrics, fibers are woven into bobbins. They can be formed into composites using heat, pressure, or vacuum to bond fibers to a plastic polymer. Around 90% of the carbon fibers produced consist of polyacrylonitrile (PAN). The remaining 10% consists of rayon or petroleum pitch. All of these materials are organic polymers characterized by long chains of molecules linked by carbon atoms. The composition of each intermediate. It varies from company to company and is generally considered a trade secret. A wide variety of gases and liquids are used in production. Some of these materials are designed to react with the fiber to create a specific effect. The materials are designed so that they do not react or avoid certain reactions with the fiber. As with the precursors, the exact makeup of many of these process materials are protected by copyright. The process for making carbon fibers is partly chemical and partly mechanical. The precursor is drawn into long strands or fibers and then heated to a very high temperature without coming into contact with oxygen. Without oxygen, fiber cannot burn. High temperature causes atoms. on the fiber to vibrate violently until most of the non-carbon atoms are expelled. This process is called carbonization, and it leaves a fiber of long chains of carbon atoms tightly intertwined with only a few non-carbon atoms. In some processes, the fibers are drawn through a series of heated chambers; in others, the fibers run on hot rollers and through beds of bulk material that are held in suspension by a stream of hot air. Some processes use hot air mixed with certain gases that chemically accelerate stabilization. Fibers can also be electrolytically coated by making the fibers positive in a bath filled with various electrically conductive materials. The surface treatment process must be carefully controlled to avoid the formation of small surface defects such as pitting that can lead to fiber failure. the fibers are coated to protect them from damage during winding or weaving. This process is called gluing. The coating materials are chosen to be compatible with the adhesive used to form the composites. Typical coating materials include epoxide, polyesters, nylon, urethane and others. After carbonization, the fibers have a surface that does not adhere well to epoxies and other materials used in composites. In order to give the fibers better binding properties, their surface is slightly oxidized. The addition of oxygen atoms to the surface ensures better chemical bonding properties and etches and hardens the surface for better mechanical bonding properties. Oxidation can be achieved by immersing the fibers in various gases such as air, carbon dioxide or ozone; or in various liquids such as sodium hypochlorite or nitric acid. The fibers can also be electrolytically coated by making the fibers the positive pole in a bath filled with various electrically conductive materials. The surface treatment process must be carefully controlled to avoid the formation of small imperfections on the surface., like holes that can cause fiber failure. After the surface treatment, the fibers are coated to protect them from damage during winding or weaving. This process is called gluing. The coating materials are chosen to be compatible with the adhesive used to form the composites. Typical coating materials include epoxy, polyester, nylon., Urethane and others. The coated fibers are wound on cylinders called spools. The bobbins are loaded into a spinning machine and the fibers are twisted into yarns of various sizes.

Development of carbon fiber

Carbon fiber is generally supplied in the form of a continuous cable wound on a spool. The cable can be a bundle of thousands of continuous individual carbon filaments held together and protected by an organic coating or size such as polyethylene oxide (PEO) or polyvinyl alcohol (PVA). The atomic structure of carbon fiber is analogous to that of graphite, which consists of carbon atoms (graphene plates) arranged in a regular hexagonal pattern, the difference being in the way these plates are intertwined. Graphite can be a crystalline material in which the plates are located. they are regularly stacked at least parallel to one another. The intermolecular forces between the plates are relatively weak van der Waals forces, which give graphite its soft and brittle properties. Depending on the preliminary stage for fiber formation, carbon fibers can also be troostitic or graphitic or have a hybrid structure with existing graphitic and turbostatic parts: Fibers made of polyacrylonitrile (PAN) are turbostatic, fibers made of carbon from mesophase pitch are then graphitic heat treatment at temperatures above 2200 ° C (high rigidity or tensile strength under load) and high thermal conductivity. One of the main limitations of many technical applications is weight, which is particularly sensitive in air traffic. The high weight of battery systems limits their use in aircraft, for example. Mass of energy storage components by optimizing individual subcomponents. Savings are achieved, but the weight is not drastically reduced and the system itself, without additional function, adds weight to the end product and becomes structurally parasitic. In the case of electric vehicles, compounds are also expected to achieve a very significant reduction in energy consumption by reducing the overall weight of the vehicle; FRP in particular has developed into a mature technology that is being further developed every day. They have electrical properties that give CFRP multifunctional properties that make it possible to combine structural performance with the storage of electrical energy. The nano-modification of polymer matrices with different types of nanoparticles seems to be a promising way to develop CFRP compounds with improved mechanical properties and multifunctionalities, since the incorporation of nano-reinforcements with different geometrical shapes, properties and surface chemistry into polymers has shown an enormous potential for overcoming has limitations on mechanical strength, which are dominated by the brittle and insulating nature of thermosets, especially in the thickness direction. Several research projects focused on the production of CFRP compounds by nanomodification of the polymer matrix and showed that the properties that provide these nano reinforcements that these are very limited by the degree of dispersion tests achieved with improved mechanical performance and multifunctionality combinations. The combination of innovative 3D printing technologies with CFRP opens up a wide range of options for lightweight construction and the production of bio-inspired components. Components due to their reliability, economy, dimensional stability, extensive material adaptation and simple manufacture.

III. CONCLUSION

Carbon fiber reinforced polymer is a strong and light material that uses carbon fiber as reinforcement with a resin matrix. Higher tensile strength, durability and the best strength-to-weight ratio make it the most reliable and efficient material in construction. the manufacture of CFRP is determined by its high potential in construction. In addition to these simple manufacturing processes, further manufacturing processes and anchoring systems must be evaluated in detail for the commercial production and use of high-strength CFRP. In order to include the CFRP in the reconditioning and reinforcement, its application methods with failure mechanisms must be precisely known, design rules and specifications for suitable applications must be defined, and research must be carried out to evaluate the behavior under different load conditions. Reinforcement CFRP is widely used in bridge construction, in the aerospace industry, in automobile construction, in the manufacture of sporting goods, etc. Therefore, the manufacture, development and improvement of CFRP will usher in a new technological era in the world of building construction.

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