COMPOSITE CARBON FIBER MATERIALS

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ABSTRACT

Carbon fiber is an important and strategic raw material for the fabrication of advance composite material. Carbon fiber polymer matrix is being extensively used as light weight material in large number of application. Aerospace structure, wind turbine blade, sport equipment off shore platform and transportation are area where Carbon fiber material is used the use of these materials result in high strength, high stiffness and very low weight. Composites are being used to improve energy generation efficiency and reduce corrosion problem. A composite material can be defined as a combination of two or more materials that results in better properties than those of the individual components used alone. In contrast to metallic alloys, each material retains its separate chemical, physical, and mechanical properties. The two constituents are reinforcement and a matrix. The main advantages of composite materials are their high strength and stiffness, combined with low density, when compared with bulk materials, allowing for a weight reduction in the finished part.

Keyword: - *Corrosion, reinforcement, matrix.*

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1. INTRODUCTION

In carbon fiber materials the two constituents are reinforcement and a matrix. The main advantages of composite materials are their high strength and stiffness, combined with low density, when compared with bulk materials and allowing for a weight reduction in the finished part. The reinforcing phase provides the strength and stiffness. In most cases, the reinforcement is harder, stronger, and stiffer than the matrix. The reinforcement is usually a fiber or a particulate. Particulate composites have dimensions that are approximately equal in all directions. They may be spherical, platelets, or any other regular or irregular geometry. Particulate composites tend to be much weaker and less stiff than continuous fiber composites, but they are usually much less expensive. Particulate reinforced composites usually contain less reinforcement (up to 40 to 50 volume percent) due to processing difficulties and brittleness.[3]

Carbon fiber is defined as a fiber containing at least 92 wt % carbons, while the fiber containing a least 99 wt % carbon is usually called a graphite fiber. Carbon fibers generally have excellent tensile properties, low densities, and high thermal and chemical stabilities in the absence of oxidizing agents, good thermal and electrical conductivities, and excellent creep resistance [7]. They have bee extensively used in composites in the form of woven textiles, prepares, continuous fibers/rovings, and chopped fibers. The composite parts can be produced through filament winding, tape winding, pultrusion, compression molding, vacuum bagging, liquid molding, and injection molding.[3]

The carbon fiber usually made up of raw material called precursor. It is combination of PAN and pitch.

1.1 Pan Carbon Fibers

PAN can be polymerized from polyacrylonitrile (PAN) by commonly used initiators, such as peroxides and azo compounds, through the addition polymerization process. The process can be either solution polymerization or suspension polymerization. The solution polymerization is preferred to be conducted in a PAN solvent so that the produced PAN solution can be used as a fiber spinning dope directly, once the un reacted monomers are removed. This eliminates the PAN drying and re dissolving processes. The solvent needs to have a low chain transfer coefficient in order to produce PAN with increased molecular weights. The most commonly used solvents are dimethyl sulfoxide, $ZnCl_2$ and NaSCN .But the molecular weight of the PAN/PAN copolymer produced by this process is usually low.[1]

1.2 Structures and Properties

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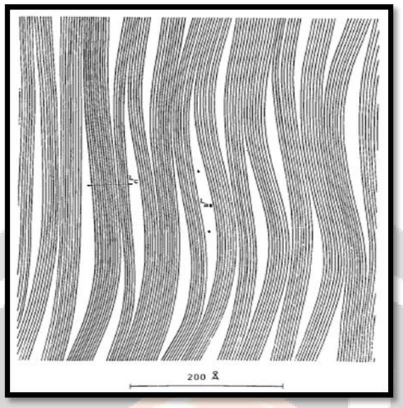

Fig-1: Microstructure of PAN carbon fibers

2. THE MANUFACTURING PROCESS

The process for making carbon fibers is part chemical and part mechanical. The precursor is drawn into long strands or fibers and then heated to a very high temperature with-out allowing it to come in contact with oxygen. Without oxygen, the fiber cannot burn. Instead, the high temperature causes the atoms in the fiber to vibrate violently until most of the non-carbon atoms are expelled. This process is called carbonization and leaves a fiber composed of long, tightly inter-locked chains of carbon atoms with only a few non-carbon atoms remaining. Here is a typical sequence of operations used to form carbon fibers from polyacrylonitrile.[4]

2.1 Spinning

The plastic is then spun into fibers using one of several different methods. In other methods, the plastic mixture is heated and pumped through tiny jets into a chamber where the solvents evaporate, leaving a solid fiber. The fibers are then washed and stretched to the desired fiber diameter. The stretching helps align the molecules within the fiber and provide the basis for the formation of the tightly bonded carbon crystal after carbonization.[4]

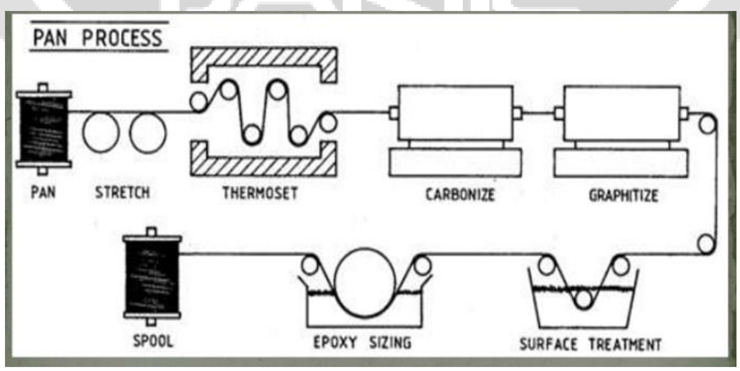

Fig-2: The Manufacturing Process of Composite Using PAN

2.2 Stabilizing

The fibers are carbonized; they need to be chemically altered to convert their linear atomic bonding to a more thermally stable ladder bonding. This is accomplished by heating the fibers in air to about 390-590° F (200-300° C) for 30-120 minutes. This causes the fibers to pick up oxygen molecules from the air and rearrange their atomic bonding pattern.[4]

2.3 Carbonizing

They are heated to a temperature of about 1,830-5,500° F for several minutes in a furnace filled with a gas mixture that does not contain oxygen. They lose non carbon atoms and bonded carbon crystals are made.[5, 4]

2.3 Surface Treatment

The next step is critical to fiber performance and, apart from the precursor, it most differentiates one supplier's product from its competitors' product. Adhesion between matrix resin and carbon fiber is crucial in a reinforced composite; during the manufacture of carbon fiber, surface treatment is performed to enhance this adhesion. Producers use different treatments, but a common method involves pulling the fiber through an electrochemical or electrolytic bath that contains solutions, such as sodium hypochlorite or nitric acid. These materials etch or roughen the surface of each filament, which increases the surface area available for interfacial fiber/matrix bonding and adds reactive chemical groups, such as carboxylic acids.[5]

2.4 Sizing

Next, a highly proprietary coating, called sizing, is applied. At 0.5 to 5 percent of the weight of the carbon fiber, sizing protects the carbon fiber during handling and processing (e.g., weaving) into intermediate forms, such as dry fabric and prepreg. Sizing also holds filaments together in individual tows to reduce fuzz, improve process ability and increase interfacial shear strength between the fiber and matrix resin.[5]

3. ADVANTAGES COMPOSITE MATERIALS

The advantages of composites are many, including lighter weight, the ability to tailor the layup for optimum strength and stiffness, improved fatigue life, corrosion resistance, and, with good design practice, reduced assembly costs due to fewer detail parts and fasteners [6]. The specific strength (strength/density) and specific modulus (modulus/density) of high strength fibers (especially carbon) are higher than those of other comparable aerospace metallic alloys. This translates into greater weight savings resulting in improved performance, greater payloads, longer range, and fuel savings.[6]

- It has long working life
- It's density is lower than density of steel

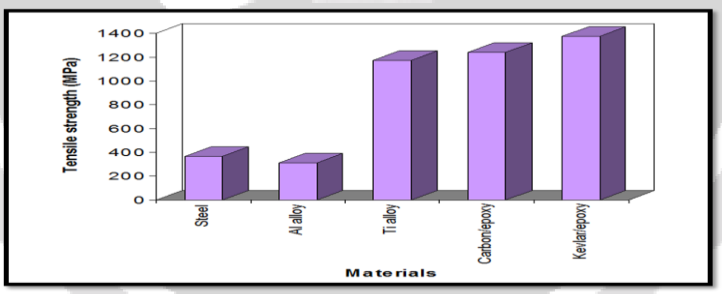

Fig-3: Tensile strength vs. materials

- High strength to weight ratio
- Low coefficient of thermal expansion
- Five times stronger than steel

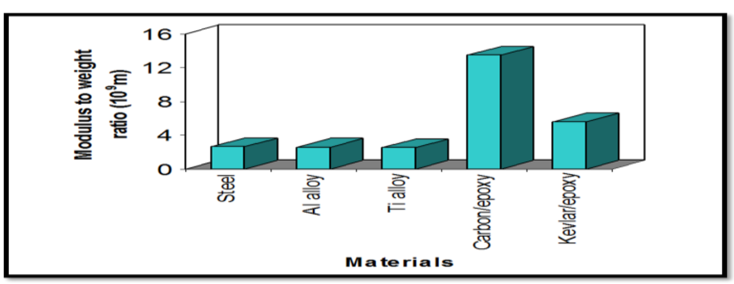

Fig-4: Modulus to Wt Ratio vs. Materials

Disadvantages of composites include high raw material costs and usually high fabrication and assembly costs; adverse effects of both temperature and moisture; poor strength in the out-of plane direction where the matrix carries the primary load (they should not be used where load paths are complex, such as with lugs and fittings); susceptibility to impact damage and delimitation's or ply separations; and greater difficulty in repairing them compared to metallic structures.[6]

4. CONCLUSIONS

Carbon fiber composites have a great future ahead of them, even if some uncertainties make it impossible to accurately foresee how the market will develop. Whether it is in the fibers themselves and the reinforcements, the thermoplastic or thermosetting matrices, the implementation processes or the design tools, there is a vast array of innovations. The task of reducing the cost of the fibers, which has already begun, will open up new promising areas.

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