State-of-the-Art Composite Design and Manufacturing for Sports Equipment

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Overview of Composite Materials

A composite material is defined as a combination of two or more materials differing in form or composition on a macro scale that retains their identities. The difficulty with an anisotropic material like composites is the number of design options which make it challenging to focus in on one parameter. Options including fiber angle, fiber type (glass, carbon, aramid), fiber content and resin type, further coupled with the numerous different manufacturing processes: wet lay-up (canoes), pultrusion (arrows and fishing rods), filament winding (bats and canoe paddles), roll wrap (arrows, fishing rods, and golf shafts), bladder molding (bike frames, tennis rackets and golf shafts), autoclave or tube clave (hockey shafts) and resin transfer molding (bats).

Performance Advantage of Composites in Sporting Goods

Composites have been increasing performance in sporting goods for many years: Tennis rackets (reducing weight and increasing the sweet spot size), Hockey sticks (reducing weight, adjusting kick point to increase energy transfer and puck velocity), fishing rods (reducing weight, increasing the sensitivity and accuracy), arrows (increasing stiffness to decrease energy loss) and Canoes (reducing weight).

Helmet Development and Testing

Composites increase the stiffness of the MLB helmet to reduce the severity index and also reduce size and weight. When a helmet takes an impact the goal is to dissipate the energy of the ball over a large area and over a greater amount of time. This is achieved by the stiffness of the helmet and when a ball impacts it the entire helmet moves as a unit instead of deforming like the current ABS shell and the player taking more of the energy. Due to the complex shape of the helmet, wet layup vacuum bagging was utilized. Carbon fiber was chosen due to its stiffness and density in its woven form to have the ability to cut patterns to wet them and lay them into the mold. Epoxy resin was chosen due to its good impact properties, good pot life and ease of use. The 100 mph MLB helmet achieved similar size and weight of the traditional helmets while greatly reducing the severity index of a 100 mph pitch. Helmet testing uses a calibrated accelerometer to record impact force from a baseball shot out of a cannon.

Conclusion

Sporting goods in many cases need to be lighter or stiffer and composites materials are utilized to achieve this goal. Due to the density and stiffness of composites one can achieve very different characteristics than metals. One can also design the material for the loading condition due to its anisotropic nature, further reducing weight and/or increasing stiffness in that plane or direction.