Research on Application of New Types of Fiber Reinforced Composites in Safety Technology

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Abstract. Application and key manufacturing technologies of new types of fiber reinforced composites in safety ranges were reviewed in this paper. To make full use of high-property kinds of fibers and develop more better-property fiber reinforced composites, the corresponding goodness and weakness and manufacturing key technologies are given so as to find appropriate and innovative new-technological cases and provide suggestions support for deeper researches.

1. Introduction
Fiber reinforced composites manufactured by woven fabrics or UD laid fabrics with high performance fiber and then cured with resins have relative density of 1.0~2.0 g/cm³ which ratio strength is 4~8 times than armor steel and ratio modulus is 3~5 times than armor steel have excellent designability, well proceeding and anti-penetration. Compared with metal armor, fiber reinforced composites also have properties such as anti-caving, anti-corrosion and anti-fragments and owe great properties in light-weight, mobility and protective ability of safety equipments [1].

Foundation research of protective fibers could be made according to mechanics principles of waves in materials. For fiber reinforced composites shocked by projectile, high-modulus, high-strength and high hardness are foundamental requirements and the main orders from strong to weak for anti-bullet properties are UD laid fabrics, twill weave, satin weave and plain weave. For anti-stabbing fiber reinforced composites, high-strength, high-hardness and high-fracture toughness are the foundamental requirements, and the main orders from strong to weak for anti-stabbing properties are woven fabrics, UD laid fabrics and non-woven fabrics.

With new kinds of fibers developping, new development opportunities for safety domains are to come out. How to make full use of new kinds of fibers is the next new issue. To make full use of high-property kinds of fibers and develop more better-property fiber reinforced composites, the corresponding goodness and weakness and manufacturing key technologies are needed to understand so as to find appropriated and innovative new-technological cases.

2. High-strength Glass Fiber Reinforced Composites
The first generation fiber reinforced composites was glass fiber reinforced composites which had been maturely applied with ripe manufacturing technology during the World War II. It was largely applied in armor protection field cause its’ low price and it was also widely used in naval vessel. However, its’ anti-bullet property isn’t well cause its’ relative density is comparatively large by comparing with composites developed latter. Its anti-fatigue property is needed to improve. Nowadays, it is usually combined with resin to develop armor system [2].
3. Carbon Fiber Reinforced Composites
Carbon fiber reinforced composites have been researched for many years. It has comparatively higher strengths and hardness in the axial direction of fiber but low fracture elongation. To improve fracture elongation is the main direction in application and research of anti-bullet field. Nowadays, electromagnetic shielding materials but not anti-bullet materials are mainly applied in safety ranges. Main proceedings include metal, SiC clad or graphite deposited on carbon fiber surface are to improve electromagnetic properties [3].

4. Aramid Fiber Reinforced Composites

4.1. Nomex Aramid Fiber Reinforced Composites
Nomex Aramid Fiber Reinforced Composites (PMIA, aramid 1313 or aramid I) have excellent heat-resistant and flame-resistant properties. It shows better size steadiness under high temperature condition but dyeing proceeding and anti-ultraviolet properties needed to improve. Nowadays, it is mainly applied in heat-resistance, anti-radiation and antistatic fields [4-6].

4.2. Para-aramid Fiber Reinforced Composites
Para-aramid Fiber Reinforced Composites (PPTA, aramid 1414 or aramid II) have high toughness, strength and modulus but anti-strength, anti-modulus, anti-moisture and anti-ultraviolet properties needed to improve. Many technologies such as control and analysis of raw materials purity, high-speed winding with dry-spraying method, multi-position&hole winding, continuous washing drying and solvent-recycling are needed to improve. Nowadays, this kind of composites is mainly applied in light-weight and anti-bullet protection fields [7-11].

4.3. Heterocyclic Copolyaramid Fiber Reinforced Composites
Heterocyclic Copolyaramid Fiber Reinforced Composite (aramid III) was early developed in Russia, and binary and ternary Copolyaramid Fiber Reinforced Composite were continuously developed and applied in missiles and motors. With the past 20 years’ development, the corresponding products have arisen to international advancement level. It has been applied in anti-bullet field and now needed to improve industrialization and output.

5. Ultra-high Molecular Weight PE Fiber Reinforced Composites
Ultra-high Molecular Weight PE Fiber Reinforced Composites (UHMWPE) have low volume denstiy and high strength, and to solve problems such as low melting point and improve co-adhesiveness between fiber and resin is the key technology to improve the corresponding properties. Main manufacturing proceedings such as dry-spraying, wet-spraying and solvent-extrusion are needed to modify. Technology of bullet-proof vest and bullet-proof helmet manufactured by UHMWPE is mature. Nowadays, the manufacturing ability is comparatively worse and there is manufacturing ability of corresponding foundational products, high-level products and corresponding qualities are needed to improve [12,13].

6. PBO Fiber Reinforced Composites
PBO has excellent high-strength, high-modulus, high-steadiness, high anticorrosion and high anti-flaming, but problems such as anti-light, axis-compressive property, and co-adhesiveness between fiber and resin are needed to solve. Composition of DAR is the key technology. However, DAR is imported difficultly. Nationally composition of high-purity DAR is limited and price is comparatively high, which limits its application. Nowadays, it is widely applied in anti-knifing products [14,15].

7. Basalt Fiber Reinforced Composites
Basalt Fiber Reinforced Composites with excellent properties such as low cost, well anti-high-temperature, acid&alkali resistance, and well electromagnetic-waves-through ability could be applied widely under wide ranges of temperatures. Nowadays, experiments show that the
anti-bullet ability is not well when it is applied alone, but it could be composed and designed to apply with other fibers under available manufacturing proceedings [16-19].

8. Cobweb Fiber Reinforced Composites
Cobweb Fiber Reinforced Composites have excellent elasticity, soft, light, anti-ultraviolet, high-toughness and thermal stability. And as environment-friendly textile material, it can be degraded biologically. To manufacture bullet-proof vest with it will have great market requirement. Nowadays, to improve output of silkworm-cobweb, cattle and sheep-milk cobweb microbe cobweb is urgent technology problem to solve.

9. Carbon Nano-tube Fiber Reinforced Composites
Carbon Nano-tube Fiber Reinforced Composites are macro-fiber materials made by super-strength and high-modulus nano-tube with axial alignment. Composition methods such as solution spinning method, array dry-pulling method, CVD spinning are needed to improve. Improvement of tube diameter of carbon nano-tube, homo-disperse, and co-adhesiveness between carbon nano-tube and resin, axial alignment degree, relative density is the key research technology and direction [20-23].

10. Graphene Fiber Reinforced Composites
Graphene Fiber Reinforced Composites are macro-fiber materials composed by nano-graphene. One kind of new type fiber reinforced composite with better properties than aramid fiber has been developed in abroad. Nationally manufacturing technology is not mature and is still in non-mature step. Composition methods such as wet-spinning, water-solvent assembly, CVD are needed to improve for higher strength of graphene fiber reinforced composites. How to align micro graphene ply and operate it is the future key technology [24-27].

11. Complex Fiber Reinforced Composites
Complex Fiber Reinforced Composites by use of nano-materials is a new way to develop new type fiber reinforced composites. Public literatures on great improvements of mechanical and heat-protective properties by use of graphene, carbon nanotube and SiO2 gas-sel are mentioned, and national technology still lies in laboratory step. Geography size of carbon nanotube, coadhesives between surfaces, dispersion, ratio of carbon nanotube to resin, alignment degree of one-dimensional and two-dimensional nano-materials are the key to improve corresponding properties [28].

12. Prospect
Nowadays, researches about new type of fibers reinforced composites are still in experimental stage, and effective analysis methods are needed to found so as to give theoretical guidances. Fiber reinforced composites for bullet-proof vest are developed to higher-strength and higher fracture strength. Technologies of the usage of nano and biology, flexture orientation, multi-function integration, electro-spinning, super-thin single fiber property characterization are the foundations to develop new types of fibers reinforced composites.

National bullet-proof materials have some gaps with abroad in output, quality and cost. And the appropriate proceedings, the technology breakthrough of fibers, enviroment-friendly and energy conservation are needed to cooperatedly develop. The research and development of new types of fiber reinforced composites would make traditional bullet-proof materials properties improve speedy, so as to provide materials foundations for better design bullet-proof products.

13. References
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