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Application of Material Used in Bulletproof Products

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Abstract:

In the world of development and advancement, the material used for bulletproof products changes from natural simple plant or simple metal to the material with high intensity. To obtain different strength level and various properties different types of materials are used. The amount of material used, impact strength of material affect the protection. In order to reduce the textile material the possibility of using shear thickening material are used. In recent days the synthetic text fiber are used for ballistic resistance. To resist the ballistic impact high performance textile material are used. For bullet proof vest Kevlar, nylon filament yarn, carbon nanotube can effectively fills the requirement. Against the high velocity ammunition multilayered armors, followed by aramid fabric are currently used. As a substitute lightness and lower cost of the jute fabric composite are also in favor. These material are used to give the protection to the product used in ballistic panel. The development of bulletproof material shows scientific strength as well as military strength of country. In this paper we highlighted the applications of some advanced composite material in field of bulletproof products.

Keywords: *Impact, Bulletproof, Fabric, Substitute, Intensity*

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Introduction

In the field of bullet-proof materials many researches have been put in many countries for the development and advancement of scientific technology. Many nations have considered the need of heavy weapons and armour which are continue in more and more development. The previous discoveries of bullet proof material gave raw steel, alloys and high performance fibers. But today the material used widely in bullet proof field covers the liquid crystal polymer matrix fibers, ultra-high molecular weight polyethylene fibers (UHMWPE), aramid fiber, ceramic composition material and many more.

By taking the products into use the physical and chemical properties like low density, high strength, good wear and high modulus, etc. should be properly checked and applied as the aramid fibers, high performance fiber have been widely accepted because of their outstanding properties which is used in bullet proof products.

A rigid liquid-crystal polymer composed with the long chain of molecules is known as aramid. Its excellent performance, high temperature resistance, high tensile strength, light weight and high regularity in its molecular structure make it suitable for bulletproof product. The relative strength of Aramid fibers is 6 times better than the high quality steel and the range of continuous applied temperature for aramid fibers is -196°C-204°C. In the field of bulletproofs the arrival of aramid material was consider as milestone.

The high modulus polyethylene and highest strength fiber in the world is Ultra-high molecular weight polyethylene fibers (UHMWPE), the molecular weight of Ultra-high molecular weight polyethylene lies from 100 million to 5oo million. It has 1.5 times higher strength then aramid fibers. In modern warfare it plays a very vital role because of its excellent properties. Ultra-high molecular weight polyethylene fibers have the good resistance and impact energy, which is very beneficial in the making of defense protective clothes, bulletproof materials like helicopters, ships, warheads, armor protection, etc.

For the bullet proof product ultra-high molecular weight polyethylene fibers become an important product in the international fiber market. It is clear that the ultra-high molecular weight polyethylene fibers are softer than Kevlar fibers. Ultra-high molecular weight polyethylene fibers have the good biocompatibility as it has good electromagnetic transmission, low coefficient of friction, good chemical resistance, anti-cutting performance and excellent impact resistance.

Composite Materials in Bulletproof Fields

Composite material used in the composition of bullet proof field is a special class of material which is designed to help or prevent the penetration of all type of shrapnel, warheads and other ballistic, material. The main functions of bullet proof material includes the ability of shellproof and ability of bearing. In generally the material used in bullet proofs field is the mixture of high performance fibers and resin matrix.

Composites Based on the Aramid Fiber

Composite material made from the system of polymer are reinforced by aramid fibers which are a class of Kevlar bullet-proof composite materials. Aramid fibers can be functionally designed because of good impact resistance, high protection performance, etc. which can also be used with other ballistic materials and composites and have many applications in the field of vehicle protection, armor protection, body protection and in many other fields. The Kevlar and resin composite material are used in the helmet with excellent shellproof performance.

The composition used for tank armor protection. The United States firstly made Kevlar and resin composite materials and then turned aramid laminate and ceramic or steel plate. The composition of armor steel plate is used to improve the anti-knock performance of vehicles. The structure of material directly affects the shocking attenuation, the material with multi-layer structure have much better shocking attenuation performance then the material with double-layer structure. The multi structure material gives excellent anti-knocking performance with good protection.

Composites Based on the Ultra-high Molecular Weight Polyethylene Fiber.

Compared with aramid fibers, the Ultra-high molecular weight polyethylene fibers have higher failure strain and have a lower modulus. The surface density of ultra-high molecular weight polyethylene fibers is lower than the Kevlar because the density of ultra-high molecular weight polyethylene fibers is much lower than aramid fibers. The Ultra-high molecular weight polyethylene fibers have higher shock resistance and higher failure strain than the aramid fiber

Because of highly focused molecular structure of ultra-high molecular weight polyethylene fiber has the excellent property of absorbing low impact energy, so when the surface is hit by the projectile, the surface produce large number of fragments with lower speed than the original speed of projectile. For the bullet proof composition the ultra-high Molecular weight polyethylene fiber is the best commercial fiber.

The bullet proof helmets made by the fiber of resin composite has been now replaced by composite reinforced by Kevlar. With lots of resin substrates ultra-high molecular weight polyethylene can be used like unsaturated polyester, polyurethane, rubber, etc.

Generally the chosen resin has good infiltration for the fiber and also improves the interface bond between matrix and fiber but the curing temperature of chosen for resin is not higher than 120°C. Because above the melting point of the ultra-high molecular weight of polyethylene fibers shows rubbery state and after heating gave larger contraction and poor scalability. Which gives great impact on the property of fibers. The application of ultra-high molecular weight polyethylene is not as Kevlar because of productivity cost but it will give a promising light and high-efficient bulletproof material.

Composites based on Continuous Basalt Fiber

The performance of Continuous basalt fiber is excellent. After the fibers carbon, aramid and ultrahigh molecular weight polyethylene fiber it is fourth high-tech fibers. Basalt fibers and the composites both are highly used in the field of defense including the equipments like rockets, missiles, nuclear sub marines, warships, tanks, fighter planes and many more equipments. For continuous basalt fiber, carbon fiber can also be the substitute because of lower cost. On basalt fibers numerous researches have been put into the field of electronics, petrochemical and fire environment.

Impact Mechanism for the Composites Reinforced by the Fiber

The main impact mechanism of composite material strengthened by the fiber it is said that the plastic sheet produce the stress wave onto the surface, which transmit along the both vertical and axial direction of the fiber. The stress will transfer to the adjacent fiber at the crossing. According to mechanism fiber can absorb the transfer the energy of impact and the composite material reinforced. In terms of plastic sheet this process can be reserved by the resin matrix.

Selection of fiber for bullet proof material

For bullet proof material particular core material which helps to stop the bullet in a specific manner is used. Today for the purpose of bullet proof material the widely used material is Aramid fibers and Ultra High Molecular Weight Poly Ethylene (UHMWPE). The fiber which are developed by upgrading the ballistic nylon is known as aramid fiber and the fiber UHMWPE is developed from polyester. The material Kevlar 149 and Kevlar 29 belongs to aramid fiber are the dominant material in the body of armor industry. The UHMWPE is another Dyneema. Dyneema is selected superior in many aspects if we compare it with Kevlar.

1. Strength:

Polyolefin is made up with an extremely long chain of polyethylene and Dyneema is a type of polyolefin. It is highly crystalline because in the structure the molecule does not have any subgroups. The high degree of crystallinity may be increase the strength of fiber even they have weak Vander Val bonds between molecules. If we compare dyneema with aramid fibers like Kevlar, the hydrogen bonding of Kevlar is very short molecular length as compare to dyneema. The strength of the Dyneema is fifteen times greater than steel and 40% stronger than aramid on the other side Aramid is five times higher than steel on an equal weight basis. The strength of dyneema is greater than the strength of Kevlar. If we consider as a bullet resistance material dyneema needs fewer layer than Kevlar fiber.

2. Chemical resistance:

Dyneema contain simple structure and contain carbon-carbon bond and carbon-hydrogen bonding. The groups like amides, esters or hydroxyl are easily attacked by aggressive agents and dyneema does not contain these groups therefore it has the resistance to most of the moisture and chemicals. On the other side aramid contain polar groups which will easily get attached with water and many other chemicals so directly used aramid is not bulletproof as well as water proof so other mixing of coating must be applied with the aramid which will increase the cost of a product.

3. Ultra-violet resistance:

The structure of aramid is aromatic which will easily degrade under the ultra violet light. But dyneema gradually degrades under the ultra-violet light.

4. Thermal property:

The melting point of dyneema is lower than Kevlar. It melts between the range of 144-152C which can be subjected to very small level of temperature therefore it will not get easily brittle but can tolerate the temperatures for short period near to the melting point. The only limiting property of dyneema is thermal property.

5. Process-ability:

Due to lower friction coefficient dyneema has good abrasion resistance, therefore it tends to bend when the loop or knot is created while aramid filament tends to break. Here dyneema is more flexible if we compare to Kevlar material.

6. Finishing:

The most important advantage of dyneema is that it does not need any specific finishing process which will reduce the complexity of cost as well as the process. On the other side Kevlar consists benzene and O-H group which reduce the ballistic strength of material. Therefore after knitting or weaving it should be thoroughly washed and rinsed to remove oil particles.

Review of literature:

Zhu and Tian, (2008): In the development of society and national defense composite material plays a very vital role. In the social progression research related to composite materials which are mostly based on the fibers and resin can speed product innovation. It will become popular in all kinds of fields because of its chemical and physical properties. In special industries like explosion-proof products, bullet-proof which further can be used for automobiles cockpit doors and wall, troops, public security guards and other special equipment composite material are essential. They also have good economic benefits and better prospects in future.

Kulkarni, (2012) Ballistic performance of various US army combat helmets are measure on the basis of design, energy absorption mechanisms materials, and performance measures. The materials like Kevlar, UHMWPE, thermoplastic are measured or elaborated I view of tensile property, weight, environmental concerns, cost effectiveness, and energy absorption capabilities. In the current helmets of US army combat the composition of UHMWPE/carbon fiber provider higher ballistic protection and it need to be further explored in the terms of cost effectiveness and manufacturing feasibility.

Sing, Malik and Lather (2013) when handgun bullet strike body armor, it is trapped in a web of strong fibers. Which will absorb and disperse the impact energy which is transmitted to the vest to bullet. dyneema fibers are one of the best fiber among the Kevlar fibers, twaron fibers and Dyneema fibers. Under the given force of a striking bullet it shows minimum deflection.

Kumaravel and Venkatachalam (2014) carbon nanotubes and nylon filament yarn will overcome the Kevlar technique and satisfy the technical requirements used in bullet proof vest. For thermal proof material developed wool/glass knitted fabric and nylon knitted fabric may be used as they can also replace the asbestos. Because of increase in number of yarns Triple cloth has more tearing strength than double cloth and higher tensile strength are caused by tearing

Fernando, *et al.* (2015) Room make for bullet to penetrate is observed and the penetrated area under microscope revealed that both welf yarn and warp has been pushed aside because of weakness in the structure of fabric. The result was in limitation of the loom where the required densities could not be obtained and the tension required is not given to the wrap and weft. Therefore the looms which are able to give tension is required, such as projectile looms which are able to give such tensions. On the bulletproof properties of dyneema fabric the Oobleck solution shows a marked enhancement which indicate that using a proper Shear Thickening Fluid for the bulletproof material would almost certainly reduce the number of fabric layers. The belongings of the developed plain laced Dyneema fabric is superior to a plain woven Kevlar fabric. They have the same specifications which are currently used in flak jackets.

Luz, *et al.* (2015) the performance of ballistic with statistical deviation is similar for the three (aramid fiber, jute fabric, and epoxy) investigated material investigated in multilayered armor system second layer material. While performing individual ballistic tests the jute fabric and plain epoxy is more efficient then aramid. Aramid dissolute less energy. Conventional Kevlar following a front ceramic is replaced by epoxy material with 30% volume of jute fabric. A negligible difference in weight and similar ballistic performance, lower cost in association with environment and social benefit of natural fiber favors the supernumerary of jute fibers composite for both aramid and plain epoxy.

Oleiwi, Hussein and Ahmed (2015) with the increase in the volume of Kevlar the properties like ultimate tensile strength, elasticity, elongation percentages at break will also increase. A good agreement with the mechanical properties is studied. With the increase in the volume fraction the value of stress also increases and with the increase of volume fraction and no of layer of the Kevlar fiber the total deformities decreases. With increase the volume fraction of reinforcement the ballistic test shows the less deformation.

Sujith, *et al.* (2015) when the bullet is strike with high velocity, to determine the stress and deformations analysis is carried out on boron fiber, Kevlar and spectra materials. From the analysis it is found that spectra fibers are best as compared to the Kevlar and boron because of minimum stresses and deformities. The desired mechanical properties like resistance to chemical reactions, higher strength, and negligible moisture sensitivity are found in spectra fiber.

Conclusion

Bulletproof composite material could widely be developed for the development and advancement of defense and country. When a material include two or more physically or chemically distinct phases on a microscopic scale is defined as composite material. The material get their individual identity and properties and make composite material but the material together produce a material system. The material have their own physical and chemical

properties like acoustic shocking resistance in addition to the specific strength and specific modulus, compared with metallic materials. Because of light weight of composite material they can be easily designed in all types of defense weapon system. Materials like boron, Kevlar and spectra are highly used in the bulletproof products every material has their own advantages and disadvantages. In different properties like higher strength, resistance to chemical reactions, negligible moisture sensitivity different material shows their importance dyneema is highly used material with good properties of bulletproof and has very less limitations. But more and more attentions will be put into the bullet-proof composite material based on the high-performance fibers in the future.

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