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A Review on Ballistic Resistant Vest

T. Kiran Kumar[1], B.N.V.D. Datta Sai[2], P. Pardha Sai[3], K.N. Sai Kumar[4], K. Eshwar Santhosh[5], G. Durga Prasad[6].

[1,2,3,4,5]Students, Department of Mechanical Engineering, NRIIT,Vijayawada-521212, Andhra Pradesh, India.

[6]Associate Professor, Department of Mechanical Engineering, NRIIT, Vijayawada-521212, Andhra Pradesh, India.

Abstract – Ballistic resistant vest is a personal armor which is exceptionally impenetrable by projectiles It serves as armor, preventing or reducing the penetration of firearm fired projectiles into the body and protecting from explosions. This paper focuses on the study of a ballistic resistant vest. The type of materials used for fabrication, the classification of the vests. These vests come in a variety of styles and offer bullet resistance depending on the threat level. The armor is made of a protective material that is bulletproof. The Different sorts of materials that can be used to create various products can achieve the necessary qualities and strength levels. The material utilized also is a key aspect for strength. Vests with low weight and thickness are the market's present trend. This would make it possible to choose the best vest type and sort based on the duties at hand and the operational environment in a simple, adequate, and rational manner.

Key Words: Ballistic, Armor, Impenetrable, Bulletproof Projectiles, Explosives, Quality.

1.INTRODUCTION

Modern light armor called bulletproof vests is created primarily to shield the wearer's internal organs from harm from bullets fired by firearms. The phrase "bulletproof vest" is misleading to many makers and wearers of protective armour. The preferred phrase for the item is "bullet resistant vest" because the wearer is not completely protected from the impact of a bullet.

Late Medieval - Francesco Maria Della Rovere hired Filippo Negroli in 1538 to make a bulletproof garment. In a similar vein, Sir Henry Lee anticipated that his Greenwich armour would be "bullet proof" in 1590. At the time, there was debate concerning its actual efficacy. Oliver Cromwell's ironside cavalry wore Capeline helmets and had two thicknesses of armor plate for protection during the English Civil War. The thicker inner layer prevented additional penetration, and the outer layer was intended to absorb the energy of the bullet. One of the first descriptions of the use of soft armor was discovered in mediaeval Japan, where the armor was made of silk.

When guns were originally invented, armour craftsmen initially sought to make up for it by strengthening torso cover, with thicker steel plates and adding a second heavy plate over the breastplate, which offered some defence against guns. However, wherever military usage of firearms occurred, heavy armor was typically abandoned.

Effective bulletproof vests were not made widely accessible to law enforcement, military personnel, and others until the plastics revolution of the 1940s. Experimental research into effective armor against gunshot persisted, mostly during the American Civil War, World War I, and World War II. Ballistic nylon was used to make the vests of the time, and they were augmented with steel, ceramic, titanium, Doron, fiber-glass, and fiber-and-fiberglass composite plates.

Up until the 1970s, ballistic nylon was the fabric of choice for bulletproof vests. Kevlar is the brand name for poly-para-phenylene terephthalamide, . It was created in 1965 by Stephanie Kwolek, a chemist at Du Pont. Kevlar was initially created for use in tyres before being used for a variety of items, including ropes, gaskets, and different parts for boats and planes. Lester Shubin of the National Institute of Law Enforcement and Criminal Justice promoted its usage in bulletproof vests in 1971 as an alternative to cumbersome ballistic nylon. Since then, Kevlar has been the accepted material. The Allied Signal Company created Spectra in 1989 as a substitute for Kevlar. The polyethylene fibre, which was once utilised for sailcloth, is currently utilised to make light weight and stronger material for bulletproof vests.

US research on bulletproof vest from fishtail cover

The trumpet is a long-lived organism that has endured for 35 million years in areas where more aggressive fish predominate. The scientists examined the fish's outer shell under an electron microscope and studied its inside structure using a tiny computerised tomography.

The exterior layer of the fish is made up of many hexagonal scales connected by connectors, much like the baby's skull, as opposed to the overlapping scales of most fish. before the hard bone is created. The lid has a solid shell thanks to this structure, yet it is still somewhat flexible.

The star structure found in the centre of each scab, which enables pressure to be spread uniformly over the surface of the body, is the primary cause of the pressure capsule, though. The researchers also discovered that the intricate collagen fibres behind the shell, which are challenging to pierce, are where the confined fish's capacity to defend itself is located.

By splitting them vertically and horizontally, the scientists examined the upper double layer's resilience. They discovered scales that were crucial to the overall structure's resilience. They will overlap in a zigzag pattern upon impact. The research team thinks that the fish's protective traits can contribute to the development of a more potent bulletproof vest.

'Shakti': World's first flexible bulletproof vest

A major in the Indian Army has now created the first bulletproof jacket for use by both male and female troops. The world's first flexible body armour is the ballistic vest designed by Major Anoop Mishra, known as "Shakti."

According to the minister, Indian soldiers who are utilising the bulletproof jackets on the borders and to fight insurgency have expressed their appreciation for them.

2. CLASSIFICATION OF BULLETPROOF VESTS:

The classification is based on the different kinds of bulletproof vests available in the market throughout the world.

Based on the analysis of the study's findings, a classification of bulletproof vests can be proposed based on the following characteristics:

- According to the NIJ ratings.
- Types of materials used for protective panels.
- Based on the gender.
- Types of wearing.

➢ According to the NIJ ratings:

The following are the NIJ ballistic protection ratings.

Level IIA

The NIJ IIA rating is intended to absorb a lower velocity 9mm round or a.40 Smith & Wesson (S&W) round fired from a lightweight handgun. Because of the thin layering of aramid fibers, armor rated at the NIJ standard IIA is most commonly lightweight ballistic vests—often weighing far less than 10 pounds. Level IIA protection is ideal for law enforcement officers seeking protection against low velocity ammunition.

Level II

The brief NIJ II rating, like the IIA rating, is capable of withstanding the impact of a 9mm or.40 SW bullet, but is slightly thicker and capable of withstanding higher velocity 9mm ammunition and a.357 Magnum round.

This means that NIJ II-rated body armour is heavier and bulkier than IIA-rated body armour. Ballistic vests with the II rating are common.

Level IIIA

While IIIA armor is thicker and heavier duty compared to level II armor, the materials used to make it are still soft and somewhat flexible. Armor with this rating can withstand.44 Magnum aa well as a 9mm submachine gun ammunition.

IIIA rating body armor will continue to be bulkier than armor with lower ratings. This level is commonly found in vests, but it is also found in other types of ballistic protection, such as the Pop Shield, a deployable shield made of Kevlar.

Level III

With the upgrade to level III, armour can now withstand small-caliber rifle rounds, such as a 7.62mm bullet fired from an AK-47 or SKS rifle.

It should be noted that armour with level III protection includes solid ballistic plates, which considerably increases the weight of the protection. This type of protection is specifically designed to deal with tactical situations and confrontations with more powerful firepower.

Level IV

Level IV of the NIJ ratings can sustain the impact of a.30 calibre armor-piercing rifle.Level IV armour is the most advanced ballistic protection available today, and it is what is issued to military personnel. The high weight of IV-rated protection makes it hard to use for those who have not been properly trained. The figure 1 shows the different levels of protections for the bulletproof vests under the NIJ standards.

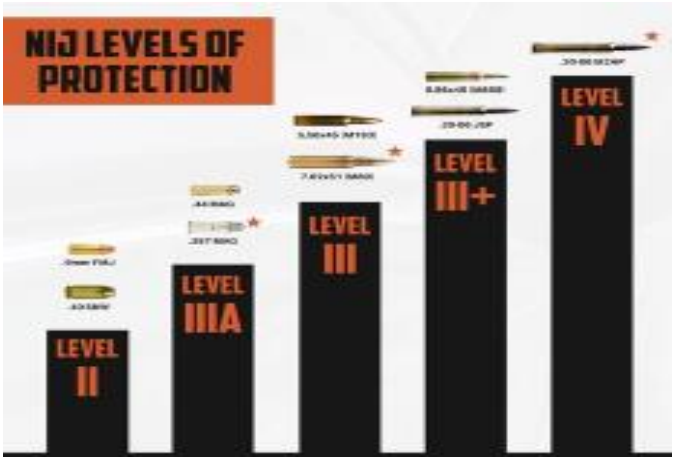

Fig-1: NIJ levels of protection.

➢ Types of materials used for protective panels:

The following are the different types of materials used for making the bulletproof vests.

- Kevlar
- Twaron
- Spectra fiber
- Dyneema

Kevlar

Stephanie Kwolek at DuPont accidentally discovered Kevlar—the registered trademark name of para-aramid polymers used in bulletproof vests and other armor applications—in 1965, while working on the development of new lightweight yet strong materials for use in tyres due to the anticipated gasoline shortage. Kevlar was later discovered to be more powerful than steel.

The peptide/amide bond, which offers structural rigidity and resistance to hydrolysis, contributes to the exceptional strength-to-weight properties. In addition to its extraordinary properties as a covalent bond, the peptide bond exhibits strong intermolecular interactions such as hydrogen bonding of carbonyl groups, which, along with the aromatic pi-pi stacking interactions, are critical in making Kevlar one of the most widely used synthetic materials in various industries.

Twaron

Twaron is an excellent fibre for making body armor. Twaron's high tensile strength provides the strength required for vests and other ballistics garments to resist penetrations, punctures, and cuts caused by gunshots, knives, shrapnel, and other threats. Twaron fibres stretch when struck by weapons and ballistics, dispersing the force generated by the impact across the Twaron's surface. Twaron is flexible, small and light, making it ideal for use as a protective clothing in addition to its high strength. As a result, Twaron is an excellent material for ballistic protection, helmets, and other safety gear, and it has military and police applications.

Spectra fiber

Spectra Shield is a composite material made from Spectra fiber; an ultra-high-molecular-weight polyethylene fiber that is 15 times stronger than steel pound for pound while remaining light enough to float. A resin system holds parallel strands of synthetic fiber lying side by side in place. Layers of the material are then cross-plied at right angles and merged together under heat and pressure to form a composite structure, allowing the material to stop projectiles more efficiently and the energy of a projectile to dissipate quickly along the length of the fibre upon impact.

These bulletproof materials have been used to protect military and law enforcement agencies around the world for over 20 years. In addition to bulletproof body armor, these materials are used in a variety of applications where light weight is critical, including military and law enforcement vests, helmets, and armored vehicles.

Dyneema

Hard armor made of Dyneema® is raising the bar for law enforcement and military officers working in high-risk environments. It offers maximum protection in a lighter package, improving comfort, maneuverability, and efficiency.

With Dyneema®, you may offer additional options for personal protection, like as side panels, while maintaining the same level of protection without adding weight to the entire armor system.

The best choice for defending cars is armor produced using Dyneema® technology. For instance, Dyneema® Force Multiplier Technology can lower the weight of armor by up to 20% without affecting ballistic performance. In comparison to conventional materials like HMPE, ceramics, fiberglass, aramid, and titanium, the end result is a vast improvement in safety, weight, space, flexibility, and cost.

- **Based on the gender:**

- for men
- for women.

For men

They are produced in accordance with specifications, in all ballistic protection classes, and with different outer casing colors and designs for different uses.

For women

All levels of ballistic protection, standards, and the colors and patterns of the outer case are made specifically for the female body, depending on the intended use.

- **Types of wearing**.

  - for visible wearing
  - for hidden wearing.

For visible wearing

This kind of armor is covered by clothing.

They are mostly utilized by the military, the police, and some security personnel. For police, military, and guards, the outer cover is produced in camouflage with various patterns on it. For police, it is made in black. With protection levels I, II under NIJ and levels 1, 2, and 3 under GOST - for security guards; and protection levels IIIA, III, IV under NIJ and levels 5, 6, and 6a under GOST - for police and military.

For hidden wearing

These armored vests are hidden beneath clothing. Security personnel, government employees, and businesspeople use them most frequently. These vests often have a black or white outer casing. These bulletproof vests largely fall under NIJ protection levels I and II and GOST levels 1, 2, and 3.

3. MANUFACTURING OF BULLETPROOF VEST:

Kevlar, a poly-para-phenylene terephthalamide, is the material used to make the modern bulletproof vests. This is a liquid polymer that is woven into fibre to create a fabric. Following a suggestion from Lester Shubin, bulky ballistic nylon was substituted with thin Kevlar when constructing commercial vests. However, Spectra, a new competing material for manufacturing bulletproof, has recently entered the market. Bulletproof vests built of this polyethylene fibre weigh significantly less than those made of Kevlar.

Manufacturing the Panel Cloth: Kevlar

The processing of the key ingredients initiates the first step in the creation of a bulletproof vest. Kevlar must therefore be created in a laboratory through a process called polymerization that involves joining substances to form a lengthy chain. To create Kevlar threads or skeins, the resulting substance, a crystalline liquid, is extruded via a metal spinneret. The yarn is then made harder by passing the thread through a cooler after that. Then, rolls of the threads are created for storage. Following Kevlar yarn production, fig.2 shows the manufacturing process, the manufacturer delivers the yarn to a thrower who twists the fiber into a texture that is ideal for simple weaving. Finally, a tabby weave or plain weaving pattern is created using the twisted fiber threads. The component is prepared to be sewn into a vest once it has been woven into a cloth.

Spectra

The only significant difference in the Spectra manufacturing method is that the polymer is spun from parallel fibers rather than being woven. The resin is then applied to the

fibers, cementing them together to form a cloth sheet. And to create a sturdy fabric, two sheets of polymer material are sandwiched between two Spectra sheets that have been joined at an angle to create a nonwoven fabric (Bulletproof Vest 2016). So, the portion of the Spectra cloth that will be utilized to make the bulletproof vest is then cut off.

Cutting the Cloth Panels

The bulletproof producers get the Kevlar and Spectra material after it has been produced and rolled together; it is their responsibility to cut the panel fabric into appropriate sizes and stitch it into a vest. Fig.3 shows the cutting of the panels because the vest needs more than one layer of either fabric, the material is ready on top of a table for simple handling. A layer of eight to twenty-five cloths produces a good bulletproof armor, according to experts. The maximum positioning of the cut sheet is decided by the makers using a cutting sheet or a computer graphic system. This is done to prevent the pricey material from being wasted.

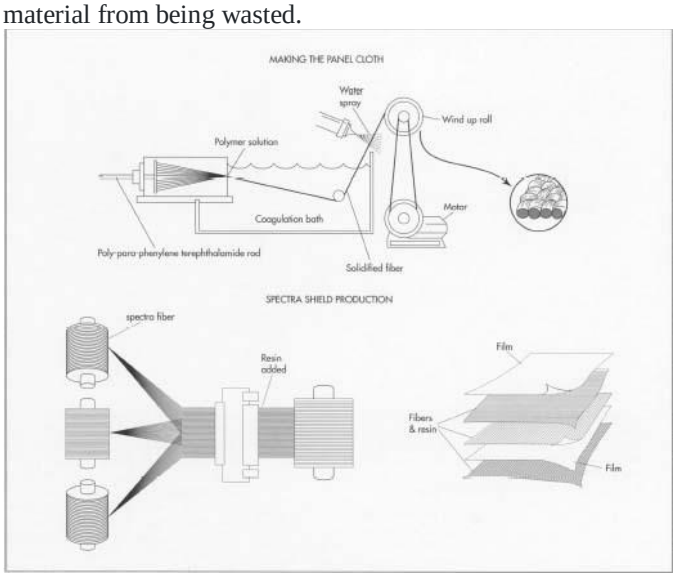

Fig-2: Manufacturing of the panel cloth

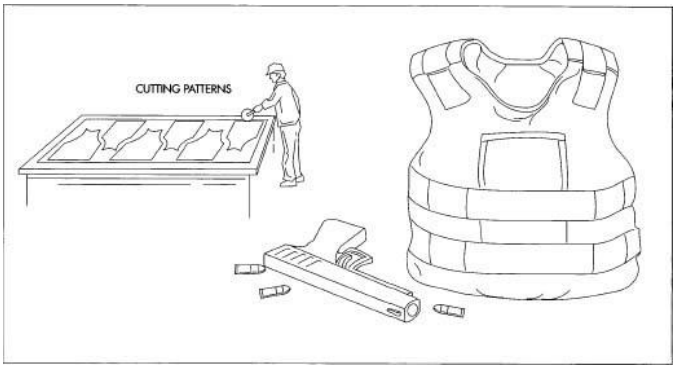

Fig-3: cutting of the panels to required patterns

Sewing the Cloth Panel Together

Only Kevlar-based bulletproof vests are put together using box or quilt sewing. As seen in the image below, box stitching creates a single box-shaped pattern in the bulletproof vest while quilt stitching produces a diamond-shaped pattern of material that is split by stitches. However, of the two techniques, quilt stitching requires a lot of work but results in sturdy panels that are challenging for users to move in a new direction. Contrarily, box stitching is rapid, simple, and comfortable for the user because it moves freely . Simply cutting the Spectra material is all that is needed to slant the fabric panel, which is then fitted into pockets in the vest.

Winding up the Vest

After the panel has been cut into the appropriate sizes, it is stitched together using tools for industrial sewing according to a standard established by the manufacturer. The finished panels are then placed into the vest shell, and the straps are stitched on. The bulletproof vest is packed and mailed to the buyer as soon as it is finished.

Because of its strength, validated results, and light weight, Kevlar and Spectra have provided the ballistic industry with superior quality, ensuring that bulletproof clothing is both light and comfortable. Kevlar and Spectra have gained widespread acclaim since the 1970s for enhancing the effectiveness of ballistic shield materials. However, the price of manufacturing Kevlar and Spectra has risen, making the materials soon unaffordable. The next generation of a more affordable and sophisticated fibre, known as DuPont and Kevlar Ap, has been developed by scientists. These two products have demonstrated more effectiveness and improved protection over Spectra and Kevlar. Additionally, the devices are made with inexpensive materials and a range of slimmer designs that increase their durability.

4. QUALITY CONTROL

Many of the same tests that are performed on conventional clothes are also performed on bulletproof vests. The tensile strength of the fiber and yarn is tested by the fibre manufacturer, and the tensile strength of the finished fabric is tested by the fabric weavers. The company also tests the le-nsile strength of nonwoven Spectra. Manufacturers of body armour evaluate the strength of the panel material (Kevlar or Dyneema), and production quality control mandates that qualified observers verify the vests once the panels are assembled.

The National Institute of Justice mandates that bulletproof vests undergo rigorous protective testing. This is different from conventional apparel (NU). Bulletproof clothing varies widely. Some defend against full metal jacketed bullets at high velocity, while others defend against lead bullets at low velocity. From least to greatest protection, vests are categorised numerically as follows: l, ll-A, ll, lll, and lv.

5. IMPROOVEMENT OF BULLETPROOF VEST

Graphene can be used in bulletproof clothing. In comparison to Kevlar, it can withstand more impact from bullets. A layer of pure carbon that is so thin and practically transparent is called graphene. It is lightweight. Researchers have screen displays of the material and its applications, such as the creation of air-powered electric generators, smartphones and other electronic gadgets, increased power and range for electric vehicles, and more.

Though scientists are still unsure of the full extent of graphene's strength, it is well recognized that it is one of the world's strongest materials.

The most recent investigation, directed by Jae-Hwang Lee of the University of Massachusetts at Amherst, examined the strength of graphene using small ballistic tests that involved firing laser-fired micro-bullets through thin layers of graphene. To detect alterations, the researchers looked at the kinetic energy within the sheets.

According to a recent study, graphite is 8 to 10 times stronger than steel. It is twice as durable as Kevlar. The impact holes left on the graphene sheets were wider than those on steel and other materials, which could cause fissures.

However, this issue might be overcome by fusing graphene with another substance.

Another option is UHMWPE (Ultra-high-molecular-weight polyethylene)

UHMWPE can be shaped in a variety of methods, such as compression moulding and ram extrusion. However, it is produced using a procedure known as gel-spinning when it is utilized for body armor. In order to produce a gel substance, this entails drawing absorbed ethylene through a grid of tiny holes. In order to generate a composite that can be turned into both flexible, lighter ballistic panels and more rigid, hard armor plates, two sections of this gel are first sealed within polyethylene film.

UHMWPE's strength to weight ratio can be up to 40% higher than para-aramid fibers (such as Kevlar), which is why it is gaining popularity in the market for body armor.

We can employ materials that can cause sweat to escape from our bodies because bulletproof vests are uncomfortable and cannot do so.

Cordura must be tough for a bulletproof vest to be utilized. Products with a high level of durability are created with Cordura, which is constructed of high tenacity fiber technologies. Heavy quality Cordura fabric is made to resist the rigors of everyday use.

Scientists in the Netherlands have created a brand-new substance that is being used in soft body armor. A fiber known as Dyneema SB61 is created from a very high-quality material, polyethylene. Pound for pound, this new material is stronger than anything else on the market.

The most recent version of the incredibly durable polymer, Dyneema, is far better at deflecting bullets.

Because Dyneema doesn't need to be waterproofed, it has the potential to create lightweight bulletproof vests.

6. CONCLUSION

Ballistic resistant vest is an interesting topic to study. The appropriate choice of methods to protect the health and life of the officers during law enforcement operations depends on having thorough understanding of modern weapons and existing means of individual ballistic protection. military, peacekeeping, anti-terrorist, and enforcement and other activities.

This paper outlines the characteristics of the bulletproof vest. We discover how to improve the performance of the bulletproof vest. using materials such as graphite, UHMWPE, and Dyneema. The paper's final finding is that Dyneema SB61, which is lightweight and waterproof, is the optimum material for manufacturing bulletproof vests.

The fabric for bulletproof vests was created at California University, and it may be used to draw sweat off the body. Thus, a soldier may wear it continuously.

When choosing the material for a bulletproof vest, the dangers and levels of appropriateness connected with high velocity impacts on the bulletproof composite material have to be identified after researching the various bulletproof vest parameters.

This would make it possible to choose the best vest type and sort based on the duties at hand and the operational environment in a simple, adequate, and rational manner.

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