Composite Armor: Market Opportunity Analysis

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Picture Source: Plasan North America

Introduction

In recent years, deadly terror attacks such as 9/11 and 26/11 have spurred more security protection to the nation and personnel. It boosted demand for armor protective systems from body and vehicle armor to cargo containers to blast-hardened buildings, to meet security needs.

The development in composite armor started since World War II, wherein armor was almost made from traditional materials such as metal plates and steel, but the concept has evolved from traditional materials to polymer composites on light weight, good impact protection, low coefficient of thermal expansion (CTE), and low cost traction. Composites offer unique advantages over solid metal, such as light weight and differential performance. On the other hand, the light weight of the armor systems increases fuel efficiency and is handy for transportability. Composites provide tremendous opportunity for armor systems composites offering more opportunities for design configurations.

A good example to illustrate the move is the evolution of the military helmet. Till 1980's, thin steel was the principal material for the manufacture of the helmets, however, these helmets were found to provide only marginal protection against fragments. During the Vietnam war, the U.S army experimented with reinforced inserts in the helmets which improved ballistic

Picture Source: TAML

protection but, at the same time, added weight and reduced the air space between the head and the helmet. By the early 1980's, the U.S. military had developed the first all-composite, 100% reinforced helmet. This development resulted in even better ballistic protection without altering the weight of the helmet. Other improvements included better head coverage and more space for ventilation. It was a successful launching pad for the composite military helmet and thereafter other countries such as the United Kingdom and South Korea also decided to use a moderate cost, moderate performance nylon composite helmet but, aramid fibre was breakthrough reinforcement as a woven prepreg with phenolic as the matrix resin for the helmets manufacturing with better ballistic resistance. Another development was UHMWPE s in a 0° and 90° crossply which was then bonded with a thermoset resin.

The major end products are military personnel protection helmets, combat vests, land mine demolition gear, special gear, radomes, naval armor, personnel carriers, body bunkers, armored boats, police helicopters, bomb blanket, pressure bottles, armored bank trucks, armored personal cars, ambulances, bus and taxi driver shields, hunter vests, fire protection, and firearm barrels (Major Applications).

Globally, composites armor products market will grow at a rate of 18 percent per year for the next five years, and reach $33 billion in 2010. It provides ample opportunity to armor system manufacturers to capitalize on the high demand. No doubt USA retains number one position which is ahead to European continent but Asia-Pacific is growing at slow pace in composites armor segments especially Japan and South Korea are doing fabulous progress.

The composite armor provides protection against bullets, explosions, crashes, shrapnel, knives, and impacts from falling or flying objects, or even from fires. Current growth in many of these markets suggests that the change in perception is underway. However, to exploit these markets, concepts and details of materials and manufacturing processes used in composite armor should be understood.

The composite armor market is largely untapped and still in development. Moreover, some of the applications will require a change in people's mindset to be fully developed because the need for armor is not now recognized.

The major composite armor fabricators are Oshkosh Corp, TenCate Advanced Composites, Hardwire LLC, Armacel Armor Corp, TAML and others.

Oshkosh Defense teamed with composites armor manufacturer Plasan North America to provide an advanced armor solution for the M-ATV. Currently, Hardwire LLC has developed a hybrid metallic/composite armor systems that reportedly offers the better protection performance as existing metal armor systems, but at a lighter weight.

Basic Concepts

The penetration from various missiles, weapons, and blunt trauma are two major assessments of the protection level afforded by a particular armor material. Most applications other than body armor focus entirely on penetration unless they are also considering some additional dangers such as fire or explosion shock. The right choices of matrix and reinforcement are essential for the development of composite armor and also withstanding the international standard.

The strength of the bond between the fibres and matrix can make major changes in the values. Energy dissipation is the key factor because armor materials work on the energy of the bullet or other missile that impact against the surface of the armor material. The dissipation phenomenon is quite complicated but some of the mechanisms are reasonably well

understood. Perhaps the most important of these is the ability of the armor material to quickly spread the impact energy sideways into a wide area which requires high strength with some percentage of elongations that does not immediately break when impacted and crashed.

Yet another factor in energy dissipation is breaking up of the bullet itself which might be caused by shattering against an outside layer of the armor. Ceramics and ceramic composites have proven to be especially useful for this purpose, in combination with aramids, UHMWPE, or fibreglass composite as a backing material.

Raw Materials

With the increasing need and demand for the composite armor, the fibre industry has also increased production capacity to tap the market. The high-strength ballistics fibres, including aramid, high-modulus polyethylene, high-strength glass and other advanced fibres are used with thermosets and thermoplastics resins and prepreg. The addition of secondary materials, such as ceramics and, perhaps metals, is also being investigated.

Para-aramid, such as Kevlar from Dupont Advanced Fiber Systems (Richmond, Va.) or Twaron from Teijin Twaron BV (Arnhem, The Netherlands), is perhaps the best-known high-performance ballistic fibres. Each has its own specific characteristics and properties, which can be exploited for different types of armor designs.

Para-aramid fibres was introduced in 1970s that imparts high tensile strength, high strength-to-weight ratio, high elongation-to-break and good damage tolerance but it has low compressive strength which makes Kevlar and Twaron a less-than-optimal choice for highly loaded structures like vehicle chassis parts. The major disadvantages of Para-aramid fibres are high moisture absorption and degradation when exposed to sunlight. Polyethylene (PE) fibres have the highest strength-to-weight ratio of all commercially available high-performance fibres. Spectra (Honeywell International) and Dyneema (DSM) are two major brands in Polyethylene (PE) fibres. PE's very low density makes the material extremely light, highly resistant to moisture absorption, along with very high elongation-to-break and good abrasion resistance, and also resisting both projectile and knife penetration. Major drawback is its difficult adhesion with resins, although surface treatments can improve interfacial bond quality.

Honeywell Specialty Materials produces Spectra high-modulus polyethylene (HMPE) and Spectra Shield four-layer laminate in roll form for hard armor applications. The Honeywell launched Spectra Shield II in 2007, with its Spectra S3000 HMPE which boost ballistic properties in Spectra Shield II laminates by more than 20 percent in armor for ground vehicles to offer higher rigidity properties in armor applications.

S-2 Glass, from AGY (Aiken, S.C.), is the heaviest fibre used in ballistic applications, with a density of 2.5 g/cm^2, its high tensile and compressive strength and greater than 5 percent elongation make it a good material choice for energy absorption.

S-2 Glass, the only S-glass fibre produced in the U.S. entered the ballistic armor market in the 1980s. The defense market looked at S-2 Glass fibres as a replacement for spall liners made with aramid. It offers better fire/smoke/toxicity (FST) characteristics and no water absorption at a lesser cost. S-2 Glass also is suitable for integrated

Picture Source: TAML

vehicle armor because it can support structural loads.

AGY material is currently being used in the U.S. Army's Humvee, the Striker vehicle, light armored vehicles (LAV) and expeditionary fighting vehicles (EFV).

Another source of advanced PE fibres used in armor is DSM Dyneema LLC. Its two brand products Dyneema HB 26 and HB 80 fibres reportedly provide added rigidity and multiple-hit protection in hard armor panels, with less weight than alternative materials. Dyneema panels used in police vehicles can weigh less than 5 kg/m2 and, hybridized with steel or ceramic strike faces, reduce a real density by as much as 75 percent.

The new ballistic material from Honeywell, Gold Shield GN-2117, has demonstrated up to a 10 percent weight reduction when compared to Honeywell's traditional Gold Flex material, which is also used in soft armor applications. The new product also is said to provide increased surface durability and chemical resistance, allowing it to meet the toughest global body armor standards for military and law enforcement applications.

Gold Shield GN-2117 builds on Honeywell's proven Gold Flex ballistic material, a soft armor material that combines Honeywell's patented Shield technology with aramid fibre. For more than 10 years, Gold Flex has been one of

Picture Source: TAML

the most widely used ballistic materials in police and military vests. The new Gold Shield GN-2117 incorporates a proprietary resin and coating system, which provides increased environmental and chemical resistance, as well as improved fragment protection.

DuPont's commercialized aramid fibre Kevlar has been used to produce a composite backing, known as a spall liner, specifically designed to deal with over-matching threats and to reduce damage caused by fragments. The Kevlar line possesses a tensile strength ranging from 525 ksi to more than 560 ksi. Kevlar spall liners are used in a number of the U.S. military's vehicle armor systems, including the M113, the Low-Signature Armored Cab (LSAC) for the Army's Family of Medium Tactical Vehicles (FMTV), and the Armor Security Vehicle (ASV).

Driving forces for Indian Composite Armor

As we discussed composite armor market represents to defence sector. The driving forces for Indian composite armor are here as below-

- Militant infiltration
- Terror attacks like deadly 26/11
- Bridge the operational gaps
- Government initiative
- Hike in defence outlay
- Modernization drive
- Nation's security Issue

In the calendar year 2009, it was huge 34% jump in allocation to plug operational gaps in the wake of the 26/11 terror attacks but in the year 2010, the defence outlay has got a measly 3.98% hike.

For the record account, the 2010-2011 defence outlay stands at Rs 1,47,344 crore compared to last year's allocation of Rs 1,41,703 crore.

Government of India has pegged INR Rs 60,000 crore in this fiscal for acquiring new weapon systems and other accessories which represents a 9.4% jump over last year's allocation, which is prerequisite for India's over 13-lakh strong armed forces.

From India, TATA Advanced Materials Ltd (TAML) was the first company which developed a light weight Bullet Proof Jacket (Personal Armor) with Indian Army co-ordination. Till date TAML has so far supplied more than 160,000 light weight Bullet Resistant Jackets to the Indian Armed Forces and overall more than 200,000 Jackets, 50,000 bullet resistant helmets to Indian and overseas defense and police forces.

Manufacturer's Consideration

The important consideration for armor manufacturers is to design protective systems for vehicles and personnel that can meet not only increasing levels of threat, but also withstand damage delivered by a variety of weapons wielded by unlikely combatants. Another one is to reduce armor system weight for security forces, military and civil, that requires high mobility and maneuverability in environments. The armor design must meet multiple functional requirements, in addition to ballistic performance, also must withstand repeated hits without catastrophic failure and remain environmentally stable.

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Conclusion

Composite armor gives a huge advantage over steel to mold unique shapes, in one piece, for greater structural integrity and without compromising protection. In short, protective armor is a diverse and growing market, and it's clear that composites will play an increasing role in many new developments.

At this moment, many aspects of the total armor market are changing. Several fibres and matrix, both new and others which have been around for years are being investigated for armor capability both alone and in combination. The methods of composite armor manufacturing process is becoming advanced while traditionally it was manufactured by hand lay up, but now may be done by compression molding, RTM, Vacuum infusion, and pultrusion.

Composite armor end products should meet specific customer requirements across a broader range of programs on a large scale, and with shorter lead times that will provide right platform to the market.

The composite armor market is looking for lighter materials right now, as the terror attack and war in Iraq continues to create demand for armor kits.

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