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A Review on Analysis and Design of Bullet Resistant Jacket -Ballistic Analysis

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Abstract: In today's world, Armor Industries are striving for the better safe body vests, having high impact energy absorbing capacity. Advanced tools like Ansys may be used for improving the vest efficiency and hence controlling the bullet. This review attempts to discuss various types of work wear (in particular Bullet proof vests)in relation to the properties of the manmade fibres and polymers from which these types of vests are made and to identify the best one based on directional deformation, total deformation, shear stresses and principal stresses, when it is subjected to a bullet impact.

Keywords: Ansys, Von Mises Stress, Deformation, Bullet proof materials, vest.

I. INTRODUCTION

A composite material is defined as a material comprising of two or more chemically and or physically distinct constituents (phases) combined on a macroscopic scale. The constituents present in the composite material retain their individual identities and properties, but together they produce a material system, the properties of which are designed to be superior to those of the constituent materials acting independently. A composite material consists of two phases one is called reinforcement and other is called matrix. These two phases are separated by distinct interfaces.

The design of composite armour is a very complex task as compared to conventional single-layer metallic armour, due to the exhibition of coupling among membrane, torsion and bending strains, weak transverse shear strength and discontinuity of the mechanical properties along the thickness of the composite laminates. This has drawn attention of several researchers to study the penetration phenomenon in composite amours [1].

The first protective clothing and shields were made from animal skins. As civilizations became more advanced, wooden shields and then metal shields came into use. Eventually, metal was also used as body armor, what we now refer to as the suit of armor associated with the knights of the Middle Ages. However, with the invention of firearms around 1500, metal body armor became ineffective [2]. In general, the battlefield demands durable, reliable, light, maneuverable and fast vehicles which, at the same time, can provide the required level of protection for the vehicle occupants. The traditional steel armor, while providing the required level of protection for the on-board personnel and do it at a relatively low cost, contributes a prohibitively large additional weight to the battle vehicles, often increasing the loads beyond the levels anticipated during the vehicle design[3].

In this review, a brief account of response of thick plate made of composite materials when impacted at high velocity by using finite element analysis , the effect of simulation on different materials to find high velocity impact on their structures and the analysis of deformation of thick plate when struck by bullet at high velocity has been done.

II. ABOUT ANSYS

Ansys is the science of predicting stress flow, Deformation and Safety.

ANSYS is used in all stages of the design process:

Conceptual studies of new designs

- Detailed product development
- Troubleshooting
- Redesign

ANSYS analysis complements testing and experimentatio n by reducing total effort and cost required for experiment ation.

Following are some of the areas, where ANSYS is being used:-

a) HVAC
b) Automobile
c) Food Processing
d) Marine
e) Aerospace
f) Electronics

III. LITERATURE REVIEW

There is significant interest within the engineering community to better understand and predict the damage sustained by composite structures under high energy

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ballistic impact. Ballistic survivability requirements are common in applications were structural integrity following high energy impact threats is critical to maintaining mission capability. A number of researchers [4-8] have investigated the ballistic impact response of composite materials using a variety of numerical models and frameworks[1].

Song-XueSha, Yan Chen and Xiao-Yu Liu[9] assessed the mechanical protective performance of Kevlar yarns and fabrics based on NIJ0101_04, the fabric is clamped at two opposite ends and subjected to impact by the 9mm FMJ at different velocities (Fig.1).

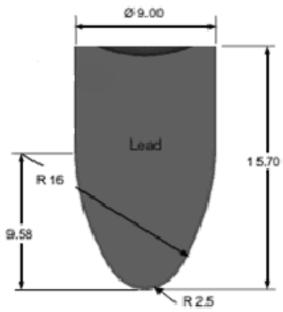

Fig.1. The geometry of the 9mm FMJ.

Simulation of impact has been done in AnsysAutodyn. by VaibhavDangwal, SaurabhGairola [10].The finished product after modeling and assembly in Catia V5 was imported as geometry in Ansys Explicit Dynamics Workbench. After selection of materials from material library, it was opened in Autodyn for loading of impact conditions. Both the lead core and outer shell are connected and are given a velocity of 700 m/s. The bullet is initially touching the assemblage of sheets (see fig.2). As the high velocity impact phenomenon is of localized nature, the boundary conditions do not influence the results and therefore only a square region of all the sheets (200 X 200 mm) was modeled. After finalizing the loading conditions, and output as Total Deformation and Equivalent (von-Mises) Stress, solver was run[11,12,13].

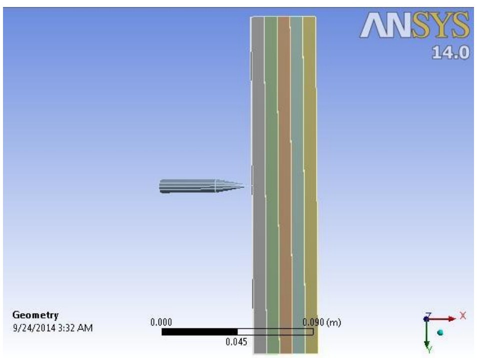

Fig.2. Initial Setting[10].

An impact phenomenon is considered as low velocity impact if the contact period of the impactor is longer than the time period of the lowest mode of vibration of the structure[14]. Apart from that, the support condition is critical since the stress waves generated during the impact will have enough time to reach the edges of the structure and causing full vibrational response. Conversely, ballistic impact or high velocity impact is involved with smaller contact period of the impactor on the structure than the time period of the lowest vibrational mode. The response of the structure is localised on the impacted area and it is usually not dependent on the support conditions (Naik and Shrirao, 2004).

However, there is also a threshold velocity which distinguishes low and high velocity impact. As implied by Cartie and Irving (2002), 20 m/s is a transition velocity between two different types of impact damage and it allows a definition of high and low velocity impacts. Similarly, the transition to a stress wave-dominated impact arises at impact velocities between 10 and 20 m/s especially for general epoxy matrix composites (Abrate, 1998).

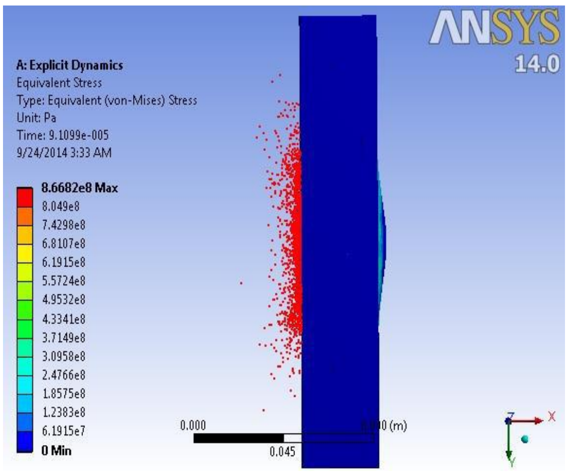

Fig. 3 Deformation after impact [10].

IV. BULLET

Bullets are made of a variety of materials. Lead or a lead alloy (typically containing antimony) is the traditional bullet core material. Traditional bullet jackets are made of copper or gilding metal, an alloy of copper and zinc. There are many other materials that are used in bullets today, including aluminium, bismuth, bronze, copper, plastics, rubber, steel, tin, and tungsten. J. hub along with his team members presented a numerical model of expansion pistol hollow point bullet penetrating the block of simulator representing the organic material (tissue). The hollow point bullet has an expansion ability to increase its wound potential, but only in case of exceeding the specific limit impact velocity[15].

Experiments and simulations done upon the gel block and the fuselage structure targets have shown a significant difference in piercing ability of the bullet Action 5 under various target conditions. In case of firing directly to the

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secondary target that is fuselage structure, the bullet penetrates all parts of the fuselage structure easily with high surplus of energy. After the simulated penetration of thin and thick parts of the human body that can be represented by the arm above the elbow and thighs of the leg, penetration ability of the bullet decreases significantly partly due to the expansion of the bullet and increasing the cross section of the bullet and partly due to lower velocity of the bullet impact as a result of deceleration in the test gel block. When considering a possible damage of the fuselage skin, the least favourable situation corresponds to the firing through gel block of the thickness less than 150 mm. In this case a large damage could occur due to tear of the skin caused by low impact energy and expanded bullet, which could have negative consequences in real flight[16].

V. WINGS AND STABILIZERS IN BULLET

New forms of shells/bullets which increases range of the projectiles 2 – 5 times is described. These forms contain in its design small special wings and stabilizers. The shell/bullet special form wings support the projectile in air, so that unlike conventional bullets or shells at that distance, these do fall to earth's surface and the projectile maintains significant kinetic energy. The important innovation is its compatibility with the conventional rifles and gun with rifled barrel. The second idea is radical change of trajectory. The projectile reaches a high altitude and glides from height using wings with subsonic speed and a good ratio lift/drag[17]. Author developed the theory of these projectiles and computed some projects which show high efficiency of this innovations. These bullets and shells can be quickly integrated into the arms industry and army because it does not require manufacture of new weapons (rifles, guns), but only change the bullets and shells [17].

VI. MATERIAL SELECTION

Composite material is a material that consists of strong carry-load materials which are embedded in a somewhat weaker material. The stronger material is commonly referred to as reinforcement and the weaker material is commonly referred to as the matrix. The reinforcement provides the strength and rigidity that is needed and which helps to support the structural load[18].

There are some advantages of composite materials:
1. Weight reduction – savings in the range 20% - 50% are often quoted
2. Mechanical properties can be tailored by 'lay-up' design, with tapering thicknesses of reinforcing cloth and cloth orientation.
3. High impact resistance – Kevlar (aramid) armor shields planes, too – for example, reducing accidental damage to the engine pylons which carry engine controls and fuel lines.
4. High damage tolerance improves accident survivability.
5. 'Galvanic' - electrical – corrosion problems which would occur when two dissimilar metals are in contact (particularly in humid marine environments) are avoided. Here non-conductive fibreglass plays a roll.

There are also some disadvantages:
1. Some higher recurring costs,
2. Higher nonrecurring costs,
3. Higher material costs,
4. Non-visible impact damage,
5. Repairs are different than those to metal structure,
6. Isolation needed to prevent adjacent aluminium part galvanic corrosion.

In study carried out by Silva et al. (2005), the researchers used AUTODYN to investigate the ballistic limit and damage characteristic of Kevlar 29/Vynilester panel. They argued that the ability of numerical model used to predict ballistic impact response of composite material depended largely on choice of appropriate material model. In the material model, it assumes that the composite material behaves as an orthotropic material system and non-linear shock effects and associated energy dependency result from volumetric material strain. Deviatoric strain contributions to the final material pressure are based on linear material response. The model also includes orthotropic brittle failure criteria to detect directional failure such as delamination. Failure occurs in brittle manner and is instantaneous in the specified failure direction. Post-failure material stiffness coefficients are assumed equal to those for the intact in direction orthogonal to the failed directions. It was found that the ballistic limit of Kevlar 29/Vynilester was correlated very well between experiment and simulation with 324.3 m/s and 320 m/srespectively. The damage mechanism involved was initially started with matrix cracking, followed by delamination and fibre breakage in the last stage. The delamination formed a circular shape when observed both experimentally and numerically.
Other approach that has been used by the researchers in simulating damage characteristic of composite laminate during impact is based on so-called continuum damage mechanics (CDM) constitutive model. This approach has been successfully implemented within LS-DYNA 3D and LS-DYNA 2D by van Hoof et al. (2001) and Nandlall et al. (1998) respectively. As the previous approach used by Silva et al. (2005), they are assumed that the response of an individual lamina is linear elastic up to failure and that in the post-failure regime a lamina is idealised in brittle manner with the dominant stiffness and strength components reduced to zero instantaneously. It is however not the case since the post-failure response of the material is able to significantly absorb the impact energy[14].
With the sympathetic nerve and parasympathetic nerve activity, the analysis of heart rate variability precisely illustrates the physiological comfort with the objective

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data. When using HRV for quantitative analysis of the bulletproof vest, it is better to adopt the ASN in a static mode and take the APSN in an exercise situation. Using a waterproof-breathable inner lining can substantially enhance comfort in the static mode. Although it is also practicable to improve comfort in exercise mode, the improvement in comfort is smaller than that in static mode. The waterproof-breathable fabric can help disperse heat generated during exerciseand improve the comfort of the bulletproof vest[19].

A. Nylon 66

Nylon 66 is frequently used when high mechanical strength, rigidity, good stability under heat and/or chemical resistance are required. It is used in fibres for textiles and carpets and molded parts.

Tsai etal. of University of Tennessee produced nanofibres from different polymers like polycarbonate, poly(ethylene oxide), polyurethanes, polystyrene, polycaprolactone, nylon 6, and nylon 66 and the fabrics made out of these nanofibres were studied for their barrier properties against microorganisms and chemicals[20].

During the second world war, American Army produced ‘flak jackets’ using steel plates with Nylon 66 backing. Nylon usually absorbs twice the amount of energy as p-aramids [Fig4] [21,22,23].

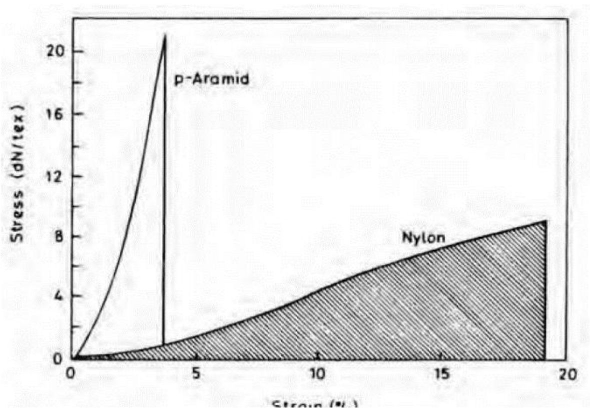

Fig. 4. Stress strain curves of Nylon and p-aramid[21].

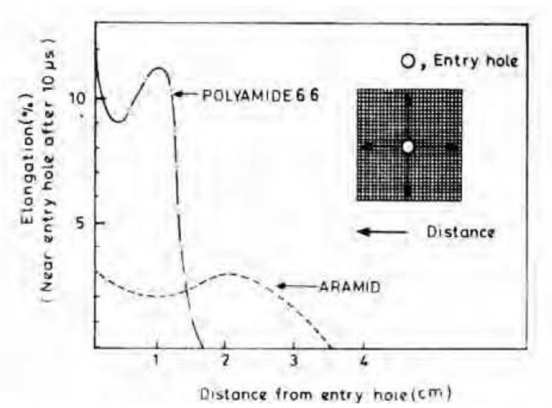

Fig.5. Ballistic comparison between Nylon66 and aramid fibre fabrics[21].

The stress propagation is more efficient with aramids which is clear in figure 5 because transverse wave velocity in p-aramid is 3-4 times higher to that in Nylon.

B. Aramids

Toward the end of the Vietnam conflict, and with the intent of designing lightweight automobile tires, the chemical company DuPontTM developed the aramid (name brand Kevlar®) fibre (DuPont 2010) . This high molecular weight fibre was found to possess high strength, high ballistic resilience and a relatively low weight – a natural fit for body armor. Kevlar® can be woven in a similar fashion to many other textiles to form sheets, which in turn are layered to form a ballistic armor system, such as a vest. One of the first Kevlar®-based armor vests was designed in 1972 by Second Chance Body Armor (Second Chance Body Armor 2010), which was a semi-flexible soft armor vest. This armor system offered protection against some pistol projectiles and explosive fragments, providing an alternative to the ageing flak vest, but was not fully accepted by the United States Armed Forces. Second chance Body Armor is still producing Kevlar® vests, mainly for law enforcement officials and is credited with saving nearly a thousand lives (Second Chance Body Armor 2010)[24].

Kevlar fibre is made of p-phenyleneterephthalamides(PPTA) which is the simplest polyamide of AABB contrapuntal directional form. The all-para aromatic polyamide is obtained from polycondensation of para-Phenylenediamine and terephthaloyl chloride. Because of the rigidity of molecular chains and the crystallization of the solution, aeolotropic microstructure could get under large shear stress in the solution. The glass-transition temperature of Kevlar is over 300℃. The decomposing temperature is 560℃. When staying in air at 180℃ for 48 hours, the strength retention rate is 84%. Kevlar fibre has high tensile strength of 0.215 N/dtex and high initial elastic modulus of 4.4～8.8 N/dtex.

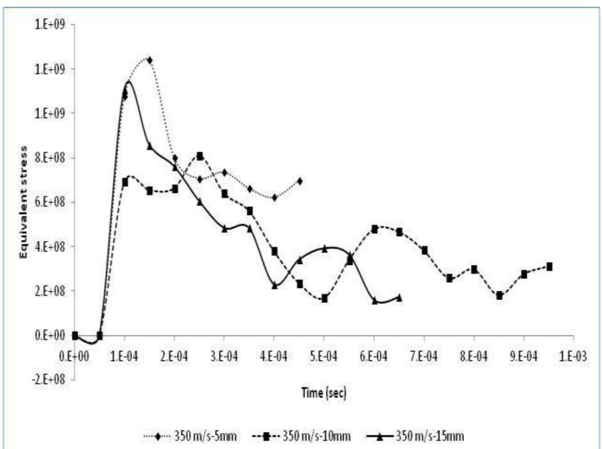

Fig. 6.Equivalent stress for Kevlar-29 at velocity of 500 m/s[11].

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Its strength ratio is five times that of steel. Kevlar fibres are often used in composite materials to resist strain, stress and flexural strength. Their properties of heat-shrinking and creep are both stable. Otherwise, the electrical insulation and chemical resistance are also high [9].

The sample that made from Kevlar-29 were exposed to take 0.07second to absorb and stop the bullet energy which indicates that there is more energy absorption by the armor and this will cause severe trauma over wearer body. Kevlar-29 armor sample were thick about 10mm and the bullet where fired to the target at distance of 50meter[2].

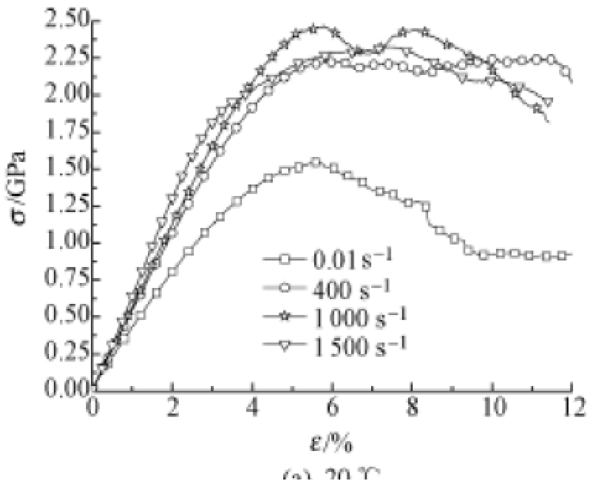

Fig. 7. Stress - strain curves of Kevlar under different strain rate at 20°C [25,9].

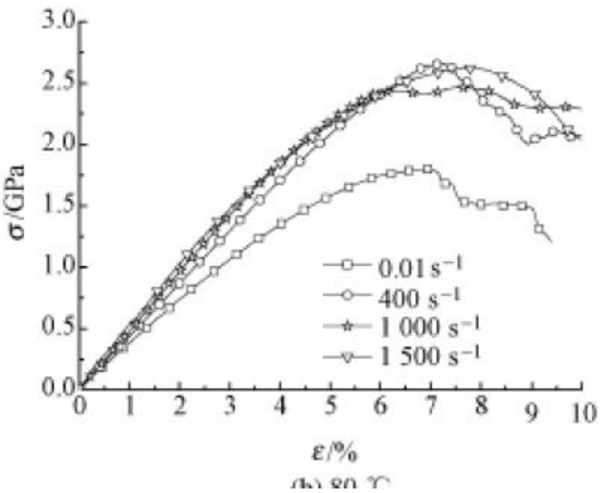

Fig.8. Stress - strain curves of Kevlar under different strain rate at 80°C. [25,9].

In dynamics analysis, the model has been extracted in IGES format. Here the material choosen is kevlar149 fibre which is subjected to boundary conditions such as the plate has been fixed and given a bullet velocity as 950 m/sec indented on a plate. The below Fig.9 shows the Maximum Principal Stress. The maximum principal stress of the plate is 1345.2 Mpa[12].

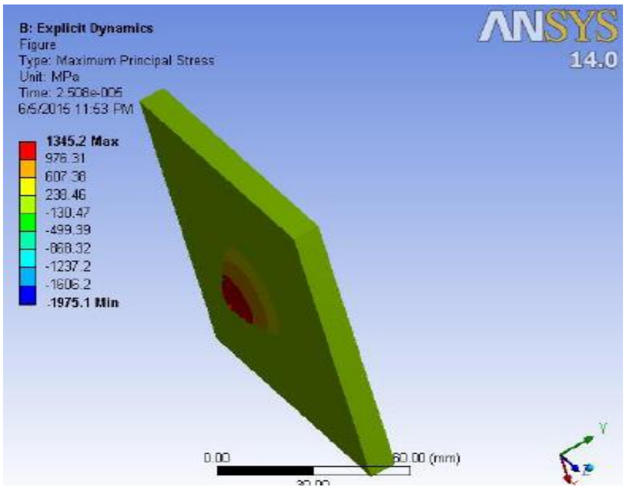

Fig. 9. Maximum Principal Stress of Kevlar149 fibre

In dynamics analysis, the model has been extracted in IGES format. Here the material choosen is Kevlar149 fibre which is subjected to boundary conditions such as the plate has been fixed and given a bullet velocity as 950 m/sec indented on a plate. The below Fig.10 shows the directional deformation. Directional deformation along y direction of the plate is 6.6024 mm[12].

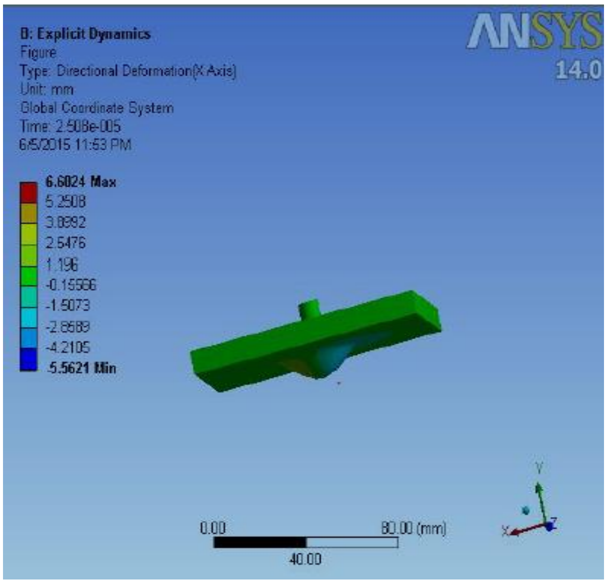

Fig.10. Directional Deformation of Kevlar149 fibre

In the research done by A.A. Ramadhan and A.R. Abu Talib[26] , the energy absorption of the composites were increased as the initial velocity increases and the numerical simulation was developed and combined with academic 3Dautodyn v.12.1 software by explicit mesh to calculate time versus velocity curves and energy absorption of Al 6061-T6 stacking sequence inside the Kevlar29/epoxy composite plates. The impact energy absorptions of numerical simulation compared with experimental work which was calculated by formula showed good agreement with maximum error of 3.64%.

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TABLE 1.PROPERTIES OF HIGH PERFORMANCE FIBRES [21].

Fibre Type	Density (g/cm^3)	Strength gpd(GPa)	Elongation %	*Modulus gpd(GPa)	Maximum use temp ^0C	[a]Wave Velocity (m/s)
ARAMIDS						
Kevlar 29	1.43	23(2.9)	3.6	550(70)	250	6996
Kevlar 49	1.45	23(2.9)	2.8	950(135)	250	9649
Kevlar 119	1.44	24(3.1)	4.4	430(55)	250	6180
Kevlar 129	1.45	26.5(3.4)	3.3	780(99)	250	8263
Kevlar 149	1.47	18(2.3)	1.5	1100(143)	250	9863
Nomex	1.38	5(0.6)	22	140(17)	250	3509
UHMPE						
Spectra 900	0.97	30(2.6)	3.5	1400(120)	100	11123
Spectra 1000	0.97	35(3.0)	2.7	2000(171)	100	13277
CARBON FIBRES						
Thornel P55(Med M)	1.8	10.8(1.7)		1940(308)	500	13081
Thornel P100(HM)	1.96	10.8(1.86)	0.38	3300(517)	600	16241
Celion 3000(HS)	1.8	25(4.0)	1.8	1440(230)	500	11304
CERAMICS						
Boron	2.5	11.6(2.55)	1.0	1800(400)	2000	12649
SiC	2.8	16(4.0)	0.6	1700(420)	1300	12247
Alumina	3.25	6.3(1.8)	1.2	730(210)	1200	8038
Nextel	2.5	7.8(1.72)	2	690(152)	1200	7797
E-glass	2.55	11.6(2.6)	3	320(72)	350	5313
S-glass	2.48	21.9(4.8)	5.3	390(85)	300	5854

*Modulus GPa= (gpd x density)/11.33; [a]Wave velocity =sqrt(Modulus/Density)

To study the damage evolution i.e. modes of damages in the composite plate(Kevlar/epoxy) due to impact, plate is impacted by conical as well as blunt ended bullet at incidence velocity of 500 m/s. Damage in the composite plate occurs mainly due to delamination caused by tensile force in the thickness direction. Shear failure is the second largest mode of damage. Bulk failure occurs in initial stage as bullet start to penetrate. Despite of modes of failure in composite plate due to impact by conical and blunt bullet, delamination of lamina and damaged area is more in the case of blunt bullet impact[27].

One of the most popular fabrics is **Twaron** CT (High Tenacity) made from high-strength fibres, used among other things as lightweight, flexible bulletproof vests. Twaron CT709 guarantees maximum protection against soft core projectiles[28]. For TwaronThe yarn count is 93tex and the weave densities are 8.3ends/cm in the warp and weft direction**.**Twaron woven plain fabric was used for the ballistic test and numerical simulation. The yarn count is 93tex and the weave densities are 8.3ends/cm in the warp and weft direction. The multiply fabric panel is layered up by a certain number of fabric layers[29].Macro-mechanical model was created as a model of layers of body armor which are made of para-aramid Twaron CT 709 woven fabric. In this type of model, textile layers are continuous membranes[30].

C. Ultra-High Modulus Polyethylene (UHMPE)

Ultra-high molecular weight polyethylene (UHMW-PE) composite is a promising ballistic armor material due to its high specific strength and stiffness[31].In all bullet proof protective-wear, there is a particular core material which contributes to the stopping of the bullet in a significant manner. Currently materials made from Ultra High Molecular Weight Poly Ethylene (UHMWPE) and Aramid fibers are used widely for this purpose.**Dyneema** and **Spectra** are lightweight high-strength oriented-strand gel spun through a spinneret. Oriented ultra-high molecular weight polyethylene (UHMWPE) fibers were discovered in the late 1970 and commercialized by DSM, branded as Dyneema®. On a weight basis, it is the strongest commercially available fibre[32].Nonwoven polyethylene Dyneema foils to protect material from abrasion and dirt. ® SB71 consists of 6 layered in low-molecular polyethylene matrix in a criss-cross (0/90°) orientation group of aligned in the same direction filament fibers SK76 and 2foils to protect material from abrasion and dirt[33].
Aramid fibers are developed by upgrading the ballistic nylon fiber while UHMWPE is developed from polyester. Kevlar 29 and Kevlar 149 are the dominant material in the body armor industry which belongs to the aramid fiber. Dyneema is another UHMWPE. The molecular formula of this polymer is the same as common polyethylene but is

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significantly different because of the very high molecular weight, from 10 to 100 times higher than commercial polyethylene moulding resin[34].

After comparing the properties of Kevlar and Dyneema, it was decided to select Dyneema as being superior in many aspects like strength , impact resistance, Dyneema gradually degrades under UV light but aramids are easily degraded.

When compared to aramid, Dyneema needs the higher energy to break, even at low elongation due to high strength and modulus and Dyneema is more flexible than the Kevlar material it may result in fewer breakages in weaving or knitting process[34].

TABLE 2. TENSILE STRENGTH (N) OF 30 CM YARN

	Kevlar	**Dyneema**
WARP		
1	143.6	246.2
2	135.7	248.4
3	136	254.0
4	138.9	247.8
5	141.5	228.4
Average	**139.14**	**244.99**
WEFT		
1	116.9	224.4
2	107.4	230.3
3	110.9	224.7
4	109.2	230.7
5	116.7	222.5
Average	**112.22**	**226.52**

TABLE 3: COMPARISON OF LOOP AND KNOT STRENGTHS

Fiber	Loop Strength		Knot Strength	
Dyneema	1.3-2 N/Tex	40-65%	1.1-1.7N/Tex	35-55%
Kevlar	0.9-1.5N/Tex	40-75%	0.6-0.8N/Tex	30-40%

In dynamics analysis, the model has been extracted in IGES format. Here the material choosen is Spectra900 fibre which is subjected to boundary conditions such as the plate has been fixed and given a bullet velocity as 950 m/sec indented on a plate. The below Fig.11 shows the total deformation. It is found that maximum Deformation in the plate is 14.212 mm. In dynamics analysis, the model has been extracted in IGES format. Here the material choosen is Spectra900 fibre which is subjected to boundary conditions such as the plate has been fixed and given a bullet velocity as 950 m/sec indented on a plate. The below Fig.12 shows the Maximum Principal Stress. The maximum principal stress of the plate is 492.2 Mpa.

From calculations and analysis it is concluded that dyneema fibers are the best among three fibers that we have analysed, as it had theminimum deflection under given force of the striking bullet[35].

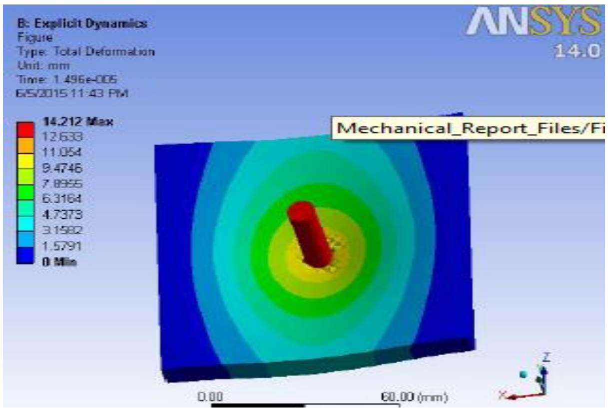

Fig. 11. Total Deformation of Spectra900 fibre

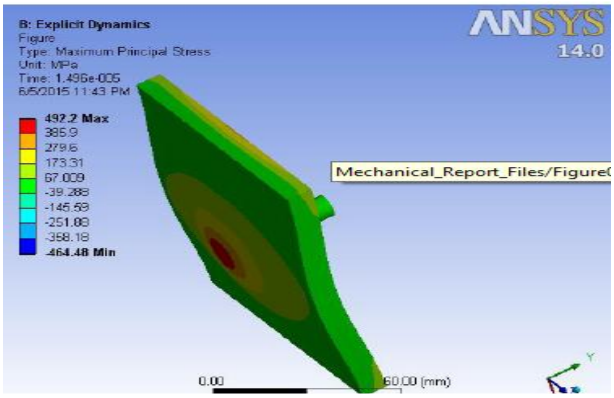

Fig.12 Maximum Principal Stress of Spectra900 fibre

D. Carbon Fibres

Sisal fiber and glass fiber as the major reinforcements and multi walled carbon nanotubes (MWCNT) as additional reinforcements are used to improve the mechanical properties of polymer composite with commercial resin ECMALON 9911 as the base material prepared by hand layup, stretched fibre and unstretchedfibre processes [36].Multilayer **Graphene** is an exceptional anisotropic material due to its layered structure composed of two-dimensional carbon lattices . Although the intrinsic mechanical properties of graphene have been investigated at quasi-static conditions has not yet been studied. Jae Hwang Lee report the high-strain rate behavior of multi-layergraphene over a range of thickness from 10 to 100 nanometres by using miniaturized ballistic tests. Tensile stretching of the membranes into a cone shape is followed by initiation of radial cracks that approximately follow crystallographic directions and extend outward well beyond the impact area. The specific penetration energy for multilayer graphene is 10 times more than literature values for macroscopic steel sheets at 600 m/s [37].Antonio Politano and GennaroChiarello [38] have demonstrated that the elastic properties in graphene/metal interfaces are the same recorded in graphite and free-standing graphene, with the exception of graphene/Ni(111), where C-C bonds are stretched by 1.48%. This implies a variation of the 2D Young's modulus by9% (310 N/m versus 342 N/m in the other systems). The excellent crystalline quality of graphene grown on metal substrates (with a reduced number of defects and grain boundaries) leads to macroscopic samples of high bending flexibility and tensile strength, which could be used for applications in advanced nanocomposites. Due to its thermal stability up to 1200 K, chemical stability and robustness, epitaxial graphene represents a promising candidate for application in nano-electromechanical devices.

The results thus far indicate only a slight increase in strength with loading rate, contrary to the glass fiber composites. The energy absorption increase with increasing loading rate is also not as great as for some glass fiber reinforced plastics. Also, the calculated value of elastic strain energy absorbed for carbon fiber composites is much nearer the measured value of energy absorption than for glass fiber composites. At this time, it is clear that energy absorption is not simply related to most experimental variables and the results of standard tests such as the Charpy test should be interpreted carefully when trying to relate them to real problems [39]. **Energy absorption capacity of carbon nanotubes under ballistic impact:** The energy absorption efficiency reaches the minimum when the bullet strikes around a height of 0.5. **Ballistic resistance capacity of carbon nanotubes:** ballistic impact and bouncing back process on carbon nanotubes. (1) nanotubes with large radii endure higher bullet speeds, (2) the ballistic resistance is the highest when the bullet hits the center of the carbon nanotube, (3) the ballistic resistance of nanotubes will remain the same even when bullets strike at the same spot as long as there is a small interval between bullet strikes[40].

E. Ceramics

Ceramics have been considered one of the most important materials for lightweight armor applications due to their low density, high compressive strength, and high hardness . Ceramic materials for using as ballistic armor must be sufficiently rigid to fragment the bullet and reduce its speed, transforming it into small fragments that should be stopped by the layer of flexible material that supports the ceramic. Thus, it is necessary that the ceramic material presents high elastic modulus and high hardness. Fracture toughness is also a very important requirement for this application. Ceramics composite materials are widely used in tank because of their high bulletproof performance. The utilization of composite materials armour in certain ballistic applications is increasingly preferred over conventional rigid metal armour systems because of its superior strength to weight ratio[41].

The main ceramic materials used commercially in the development of ballistic armors are Al_2O_3, B_4C, SiC, and ceramic matrix composites (CMCs) such as Al_2O_3/ZrO_2 system. High cost, processing hindrances, and restrictions to predict ballistic performance from the properties of the material are some drawbacks of ceramic armors [42].
The Ceramic to make passivation of bullet shell and stop advancing function, has reduced the bullet performance of penetration. If ceramic appear interface destroy, crackle and is it come back stress destruction, that loses and resists the performance of bullet-proof. In order to prevent this situation, need paying attention to bond resin, strength of ceramic, size, thick and resistance of stress wave[43].

F. Mild Steel

A Deb along with his team members gives a comprehensive finite element-based study of ballistic impact on moderately thick mild steel plates of different grades with a low- calibre jacketed projectile. A comparison of three different modelling techniques was done which removes a degree of confusion that may have existed in published literature on preference for any of these approaches. The ability of the current modelling techniques in predicting residual velocity and plate failure mode indirectly confirms earlier observations of experts that thermal effects are not significant for velocities not exceeding the ordnance range. The present convergence study also establishes erosion of projectile copper sheath increases substantially. Such partial-to-significant erosion of projectile sheath has been observed in actual tests. The presence of localised bulging of perforated target plate with minimal dishing (i.e., plate bending) in shell-, solid-, and axisymmetric-based modelling of target plate has been reported in tests at velocities substantially higher than ballistic limit. [44].The study has shown that the predictive capability for penetration of steel core bullet is quite good

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with Radioss non-linear explicit analysis. It also helps to get the steel plate behavior under dynamic impact loading. It has been shown that the simulations could catch the main features of the experiments (especially the velocity, and kinetic energy of the projectile)[45,46].

In research done by Rajesh P Nair, Alex AEarali both projectile and target are made of steel. During impact and penetration there will be a rise in temperature in both projectile and target. To capture these temperature effects, thermal properties are used in simulation of impact. Johnson Cook model is used for both material deformation and failure simulation. Johnson Cook model is a strain rate and temperature-dependent viscos-plastic material model. Failure model used is Johnson and Cook [47].Failure criterion which is based on the continuum damage mechanics[48].

Impact damaged area for medium velocity impact is calculated using thermography and that is validated by the x ray radiography. Transmission mode with 50 Hz thermography is coinciding with x ray radiography. From the x ray radiography image it is concluded that the material is damaged for full depth even though the bullet is not fully penetrated [49].

VII. LIMITATION OF CURRENT TECHNOLOGY OF BULLET PROOF JACKETS

1. A full body suit would likely double the weight of the armor and reduce the soldier's mobility to a waddle and unable to bend.
2. Most ceramic armors used today employ alumina (Al_2O_3) as the ceramic material. When weight reduction is a primary concern , silicon carbide (SiC_3) and boron carbide (B_4C_3) ceramics may be used; however , their high cost as compared to alumina limit their use.
3. The plates will stop one armor piercing 0.3-0.6 or 7.62*54R round. Subsequent protection against such round is not guaranteed .
4. Body armor will not stop 0.50 Brouning machine gun(BMG) or equivalent Russian heavy machine guns rounds.
5. They don't protect against other injury (eg knives).
6. Aside from the danger of heat related injuries , BPV may contribute to severe discomfort problems.

VIII. SCOPE

1. Bulletproof vests for the armed forces are set to get lighter by around 2kg as scientists at Patiala-based Thapar University are working on a polymeric liquid which will replace the fibre used in such jackets at present. In a "Make in India" initiative, the scientists are developing the new vests under a project sponsored by Defense Research and Development Organization (DRDO).The bullet proof vests currently used by the security forces weigh around 3.8kg and are made bullet resistant using a fibre named Kevlar (polyparaphenyleneterephthalamide), whose 2040 layers are packed inside the jacket. The new bullet resistant liquid will reduce the number of layers up to four.
2. Experiments carried out at Rice University show graphene is 10 times better than steel at absorbing the energy of penetrating projectile. They have been known to be 100 times as strong as steel .CNT's are extremely light.
3. Nanotechnology can assist the design of super strong fibers for ballistic armors applications. Molecular design can assist the alignment of Nano fillers in polymeric fibers. Fabrication and Study of Mechanical.
4. In Medical field available some Medicines and liquids, that is very useful to stop blood flow from injury within 8 seconds and injury recovery will be fast so these type of things put in the jackets after that soldier have more safety.

IX. CONCLUSION

The modular jackets are meant to provide "graded level of protection" depending on the mission to be undertaken. The jacket would weigh less than 4 kg with a trauma pad with all around soft armor plate including front, side, back, collar and neck for low risk/threat missions.

For many years , modern bullet resistant vests were made from woven Kevlar , but newer materials have since been developed that are lighter , thinner and more resistant , although much more expensive. The cost of bullet proof vests ranges anywhere from $100 to more than $1300 for top quality, resistant ones [50].

The term "bulletproof" is a misnomer since the vests depending on their rating may provide little or no protection against rifle , ammunition , unusually high velocity pistol ammunition , pistol ammo fired from a rifle barrel , armor piercing ammunition and sharp edged or pointed instruments (such as knives). Additionally, projectiles that are successfully stopped by armor will always produce some level of injury, resulting in severe bruising , broken wounds , serious internal injuries or even death.

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