IARJSET

ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 8, Issue 7, July 2021

DOI: 10.17148/IARJSET.2021.8776

DESIGN AND ANALYSIS OF A BULLETPROOF KEVLAR VEST

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Abstract: In today world, Armour Industries are striving for the better safe body vests, having high impact energy & absorbing capacit**y.** This project aims at studying various composite materials used in bullet-proof vests and to analyse their effectiveness by using FEM technique & advanced tools like Ansys. In this project, analysis was done for Kevlar vest by taking three different thickness of material and grades of Kevlar as 49, 29, and 149. And to identify the best one based on, total deformation, Equivalent stress and Maximum principal stresses.

Keywords: Solid-edge, Ansys, Principle stresses, Deformation

I. INTRODUCTION

Composite materials are increasingly used in many military, civil and space applications. Spacecraft face various impact phenomena in space, among which the impacts of orbital debris are of great concern. 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 has excellent mechanical properties such as high specific strength, specific rigidity, corrosion resistance and longer fatigue life

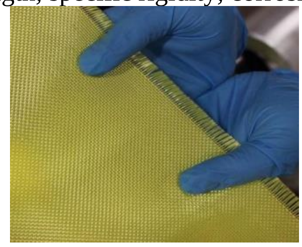

Fig.1.1: Kevlar Material

The means engaged with making Kevlar material are; initial step is to create the fundamental plastic from which Kevlar is made (a substance called poly-para-phenylenetere-phthalamide no big surprise they call it Kevlar). Second you need to transform it into solid strands. So the initial step is about science; the second one is tied inwith transforming your concoction item into a progressively helpful, pragmatic materialas appeared in the fig.1.1 Polyamides like Kevlar are polymers (colossal atoms made of numerous indistinguishable parts combined to frame a long chains) made by rehashing amides again and again.

TYPES OF KEVLAR MATERIAL

1. Kevlar 29 – Multipurpose yarn
2. Kevlar 49 - High modulus yarn
3. Kevlar 68 - Moderate modulus yarn
4. Kevlar 100 - Colored yarn
5. Kevlar 119 - High elongation yarn

1. Kevlar 29:

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The first group of item types of Kevlar having comparative malleable properties with a few decitex and completions. These yarns zone unit used in direction applications, ropes and links, ensuring clothing like cut-safe gloves, in life security uses like protective caps, transport shielding and plates, and as elastic support in tires and car hoses.

2. Kevlar 49:

High modulus kind utilized fundamentally in fiber optic link, material procedure, plastic fortification, ropes, links, and composites for marine hardware and part applications.

3. Kevlar 119:

Higher stretching, adaptable weariness safe yarn sorts found in mechanical elastic product, similar to tires, car belts and hoses.

II.ABOUT ANSYS AND FEM

HYPER-MESH

Meshing is a Process of sub-diving the structure to Finite Elements or The processof changing the Infinite number of points to Finite Number of nodes and elements. This process is also called as Discretization (Meshing). This is one of the Timing Consuming Process in Finite Element Analysis. Finite Element Method reduces the degrees of freedom from infinite to finite with the help of discretization ormeshing (nodes and elements).

One of the purposes of meshing is to actually make the problem solvable using Finite Element. By meshing, you break up the domain into pieces, each piece representing an element. 3D elements should be used be used when all dimensions are dimensions are comparable. Parable. X-Y-Z Element, Element shape – Tetra, penta, hex, pyramid.

ANSYS

Ansys is the science of predicting stress flow, Deformation and Safety. ANSYS issued in all stages of the design process: Conceptual studies of new designs, detailed product development troubleshooting, Re design.

Ansys analysis complements testing and experimentation by reducing total effort and cost required for experimentation. Following are some of the areas, where ANSYS is being used:

1. HVAC
2. b)Automobile
3. c)Food Processing
4. d)Marine
5. e) Aerospace
6. f) Electronics

III. LITERATURE SURVEY

In early modern era: In 1538, Francesco Maria Della Rovere commissioned Filippo Negroli to create a bulletproof vest. In 1561, Maximilian II, Holy Roman Emperor has testing his Armour against a gun fire. In 1590 Sir Henry Lee expected his Greenwich Armour must be "pistol proof". The actual effectiveness of the vest was controversial at that time.[2]. The etymology of "bullet" and the adjective form of "proof" in the late 16th century would suggest that the term "bulletproof" originated shortly thereafter. At the season of English Civil War Oliver, the Cromwell's Ironsides rangers was prepared, Capelin protective caps and black powder gun confirmation cuirasses which comprised of two layers of reinforcement plate (in later examinations including X-beam a third layer which was found and put between the external and internal layer). The external layer was intended to assimilate the effect of the shot's vitality and the thicker internal layer ceased further infiltration of the slug. The shield was harmed in all respects gravely however yet left seriously marked was still in useful condition

Recent years: throughout the Nineteen Eighties, the US military issued the PASGT Kevlar vest, tested in private at NIJ level IIA by many sources, ready to stop piece rounds (including nine-millimetre FMJ), however meant and approved just for fragmentation. European country issued an analogous rated vest known as the Splitter Schutzweste. [Citation needed]. Kevlar soft armour had its shortcomings as a result of if "large fragments or high-speed bullets hit the vest, the energy may cause critical, injury injuries"[citation needed] in designated, important areas. Ranger coat of mail was developed for the yank military in 1991. though it had been the second fashionable US coat of mail that was ready to stop rifle calibre rounds and still be lightweight enough to be worn by army unit troopers within the field, it still had its flaws: "it was still heavier than the at the same time issued PASGT (Personal Armour System for Ground Troops) anti-fragmentation armour worn by regular army unit and didn't have a similar degree of trajectory protection round the neck and shoulders.

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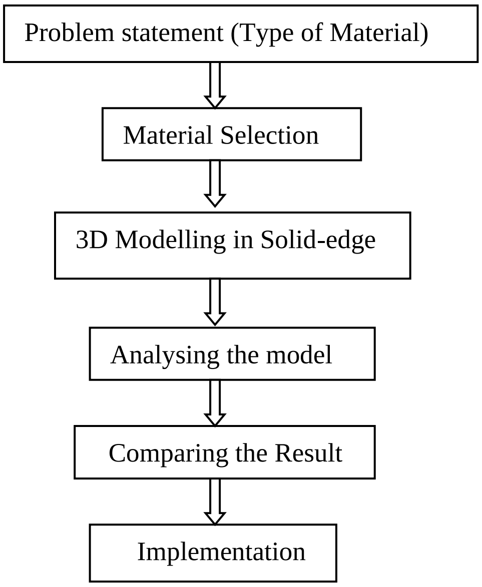
IV. METHODOLOGY

The design methodology helps us to find the best solution for every material design and selection. A systematic approach much be followed to obtain the appropriatesolution.



V. MATERIAL SELECTION

Current bullet-proof vests are made of fibrous materials by layers placed one over the other. Upon effect the material retains the vitality of the shot and scatters it all throughthe material. This hinders the slug and prevents it from entering the body. There are currently used three materials to produce bullet-proof vests are Kevlar, Twaron, Dyneema.

Kevlar Material.

Kevlar is one of the advanced and supernatural materials that individuals talk pretty much all the time without truly clarifying whatever else. "It's made of Kevlar," they state, with a cognizant gesture, as though that was all the clarification you required. Kevlar is essentially a very safe plastic. On the off chance that this appears to be insignificant, recollect that there are plastic and plastic materials. There are actually many manufactured plastics created by polymerization (which consolidate long chain particles) and have altogether different properties. The astonishing properties of Kevlar are expected partially to its inward structure (the manner by which its particles are normally sorted out in customary and parallel lines) and

Mostly to the manner by which they are made of filaments that are associated with one another.

Advantages and Applications of Kevlar Material

1) **Advantages**

Higher tensile modulus than steel wire

High breaking tenacity

Very high kinetic energy absorption

2) **Disadvantages**

Low Thermal shrinkage

Low Electric Conductivity

3) **Applications**

Brake pads
Gaskets
Clutches
Marine Composites
Armour system
Automotive Hoses& belts Reinforcement
Fibre optics

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BULLET SPECIFICATION

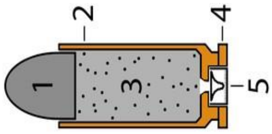

Fig-2

1) Bullet, as the projectile
2) Case, which holds all parts together
3) Propellant, for example gunpowder or cordite
4) Rim, which provides the extractor on the gun a spot to hold the packaging toexpel it from the load once discharged
5) Primer, which ignites the propellant

IMPACT TESTING METHOD

The kinetic energy of the mass ($Mv^2/2$) is transformed into stored energy in the support. When the bullet strikes on the bullet proof material like Kevlar, this bullet is caught in a web of very strong fibres shown in the fig.3.. Hence all the fibres absorb and distribute the impact energy of the bullet causing the bullet to deform like a mushroom due to impact force of the bullet. There are numerous reasons for auxiliary harm, for example, dampness ingestion, weakness, wind blasts, warm pressure, erosion, fire, lightning strikes, or even effects from different sources.

Fig-3 Bullet due to impact on Kevlar

Once this vest is tested in software by applying the bullet force on the composite, the result is safe then the vest can be manufactured for further use ages. Before the vest being sold in the market it is been experimentally checked for bullet impact force.The bullet used for test is 9×19mm parabellum, weight of bullet is 0.0075Kg, muzzle velocity of the bullet is 380m/s, number of Kevlar layers used are 24,26 for analysis

Fig-4 Bullet Impact Force

VI. RESULTS

Case	Composite Thickness t_c (mm)	Material for Bullet ProofVest	Deformation of composite due impact (m)	Theoretical Stress σ_c $(\frac{N}{mm^2})$	AnalysisStress σ $(\frac{N}{mm^2})$
1	6	Kevlar 29	0.016009	149.39	149.78
		Kevlar 49	0.016009	153.62	148.5
		Kevlar 149	0.016008	160.62	147.9
		Kevlar 29	0.016010	1160.4	1148

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2	7.2	Kevlar 49	0.0160074	1550.3	1511
		Kevlar 149	0.0160075	1529.2	1518
3	7.8	Kevlar 29	0.0160083	11372	11368
		Kevlar 49	0.016007	1146.8	1139.4
		Kevlar 149	0.016007	1148	1140

VII. CONCLUSION

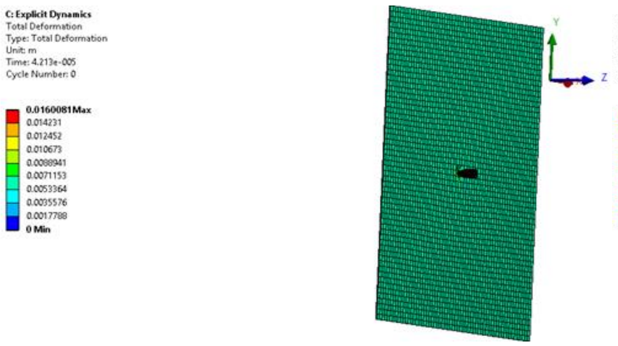
Case:1 : In this result analysis the thickness of composite is 6mm (14 layer) and three different grades of Kevlar like 29,49,149 is taken to compare and check the best result like les deformation (0.016009) of the material and higher stress value bullet of 149.78 N/mm2 deformation due to impact on composite.

Case 2: In this result analysis the thickness of composite is 7.2 mm (18layers) and three different grades of Kevlar like 29, 49 and 149 is taken to compare and check the best results like less deformation(0.0160074mm) of the material and higher stress value 1511(N/mm^2) of bullet deformation due to impact composite.

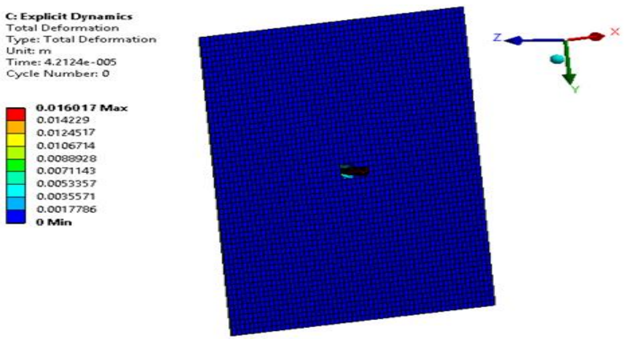
Case 3: In this result analysis the thickness of composite is 7.8 mm (20layers) and three different grades of Kevlar like 29, 49 and 149 is taken to compare and check the best results like less deformation (0.016007mm) of the material higher stress value 1139.4(N/mm^2) of bullet deformation due to impact on composite.

Case 1: 14 layers of Kevlar:

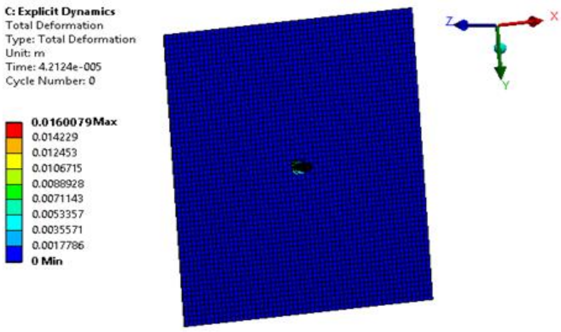
a. Total deformation of the bullet at which it deforms by impact on the composite material (Kevlar 49, Kevlar29, Kevlar149) value are 0.0160081m, 0.016017m, 0.0160079m as shown in fig.5.8, 5.9, 5.10 by using explicit analysis for Kevlar material.



Total Deformation (Kevlar49)



Total Deformation (Kevlar29)



Total Deformation (Kevlar149)

Case 2: 18 layers of Kevlar:

Maximum principal stress of the bullet at which it deforms by impact on the composite material (Kevlar49, Kevlar29, Kevlar149) value are 1.151×10^9Pa, (1151MPa), 1.1484×10^9Pa, 1.158×10^9Pa, as shown in fig.5.11, 5.12, 5.13 by using explicit analysis for Kevlar material.

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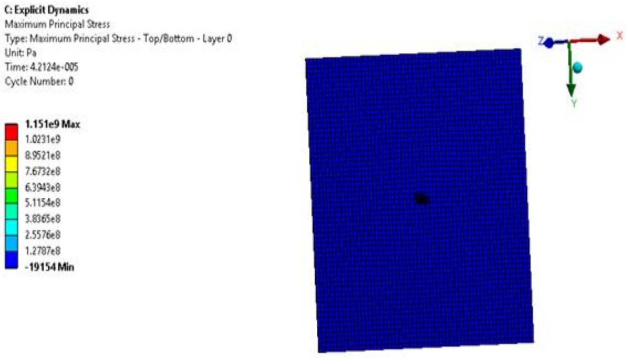
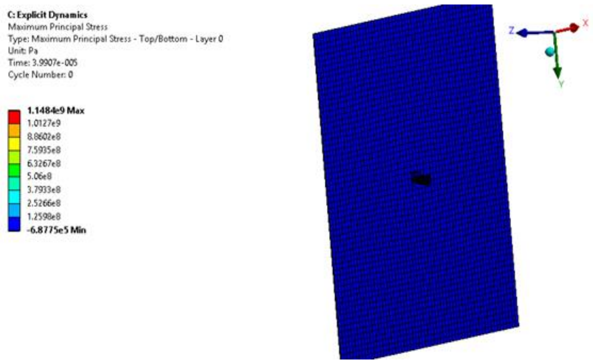
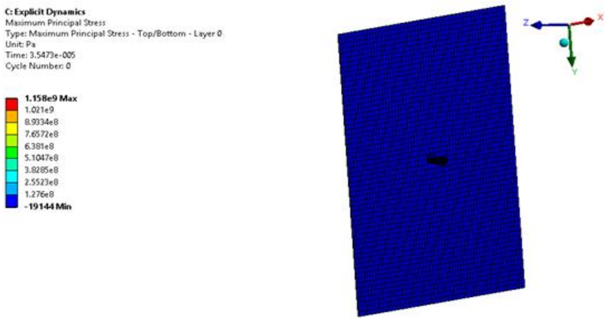


Maximum principal stress (Kevlar49)

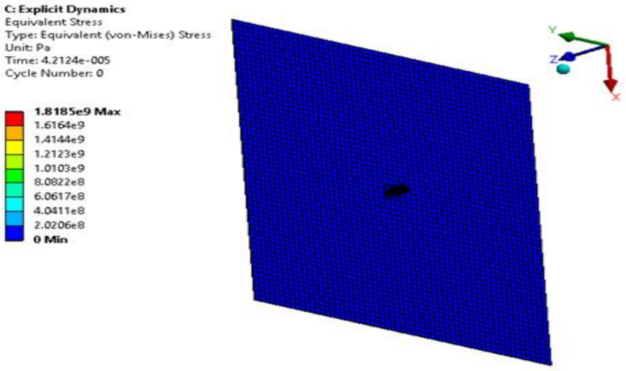


Maximum principal stress (Kevlar29)

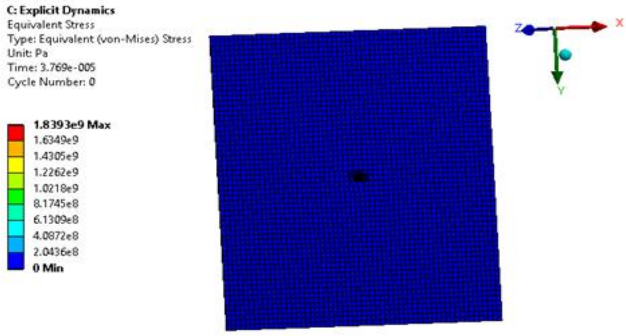


Maximum Principal Stress (Kevlar149)

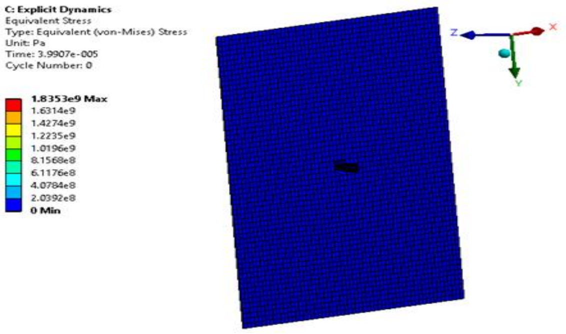
Equivalent stress of the bullet at which it deforms by impact on the composite material (Kevlar29, Kevlar49, Kevlar149)value are 1.8185× 10^9Pa, 1.8393× 10^9Pa, 1.8353×10^9Pa as shown in fig.5.14, 5.15, 5.16 by using explicit analysis for Kevlar material.



Equivalent Stress (Kevlar49)



Equivalent Stress (Kevlar29)



Equivalent Stress (Kevlar149)

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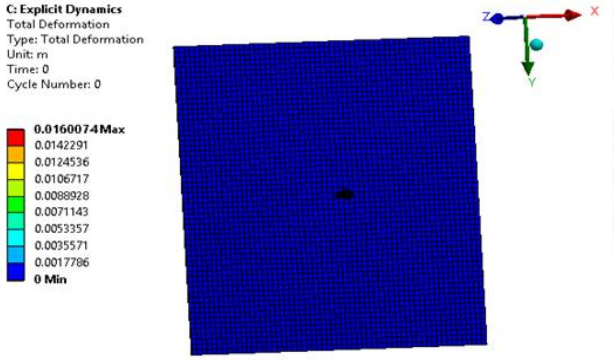
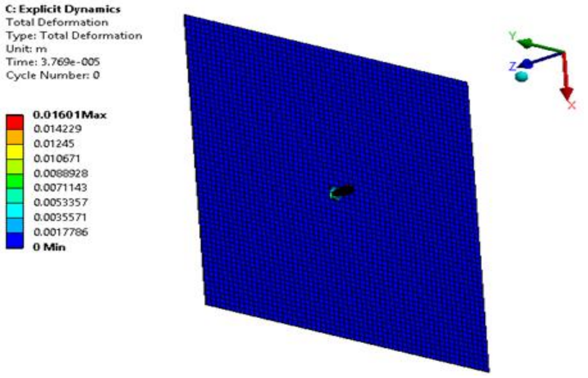
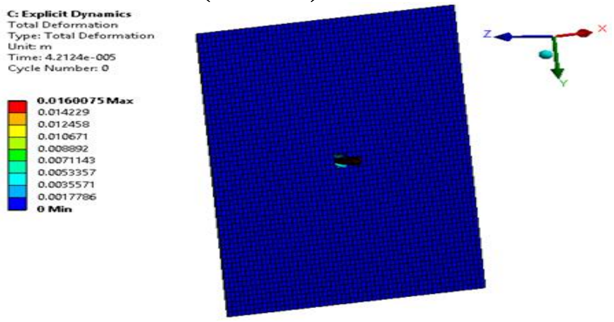
Total deformation of the bullet at which it deforms by impact on the composite material (Kevlar29, Kevlar49, Kevlar149) value are 0.0160074m, 0.01601m, 0.0160075m as shown in fig.5.17, 5.18, 5.19 by using explicit analysis for Kevlar material.



Total Deformation (Kevlar49)



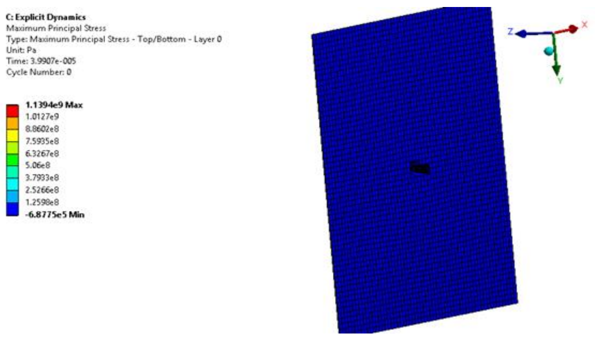
Total Deformation (Kevlar29)



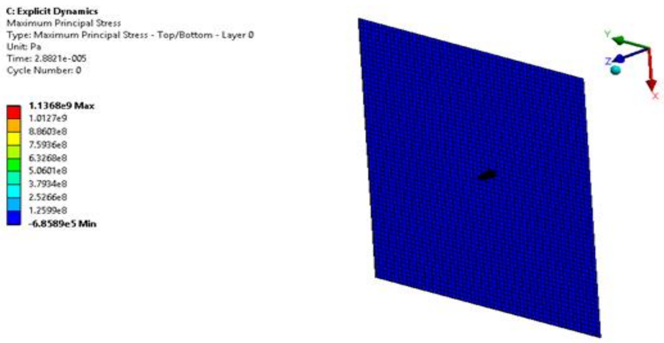
Total Deformation (Kevlar149)

Case 3: 20 layers of Kevlar:

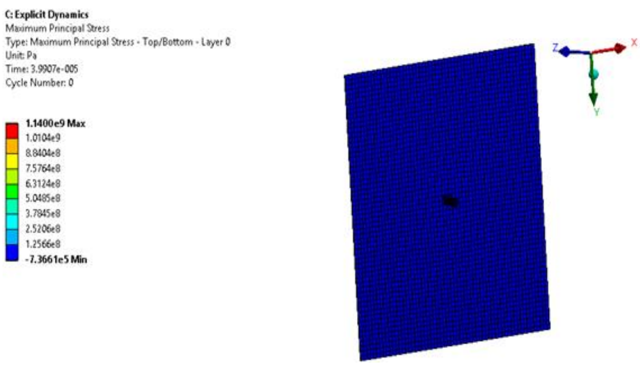
Maximum principal stress of the bullet at which it deforms by impact on the composite material (Kevlar49, Kevlar29, Kevlar149) value are 1139.4MPa, 1136.8MPa, 1140MPa as shown in fig.5.20, 5.21, 5.22 by using explicit analysis for Kevlar material.



Maximum Principal Stress (Kevlar49)



Maximum Principal Stress (Kevlar29



Maximum Principal Stress (Kevlar149)

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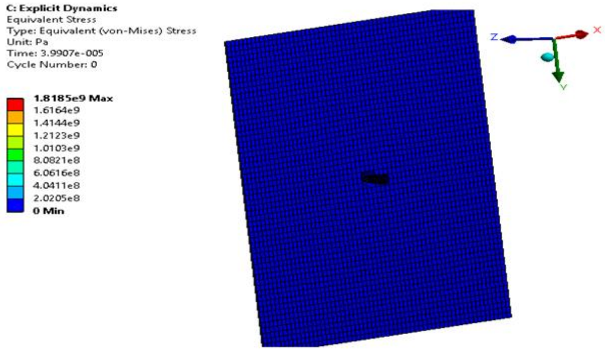
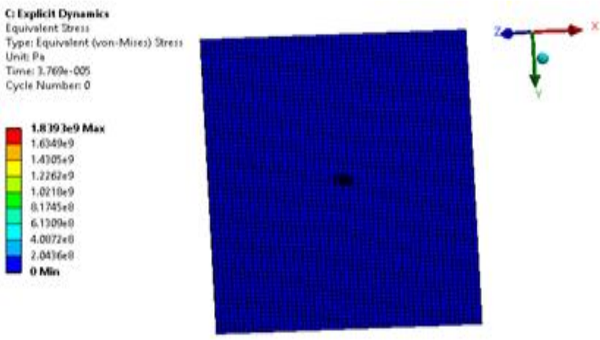
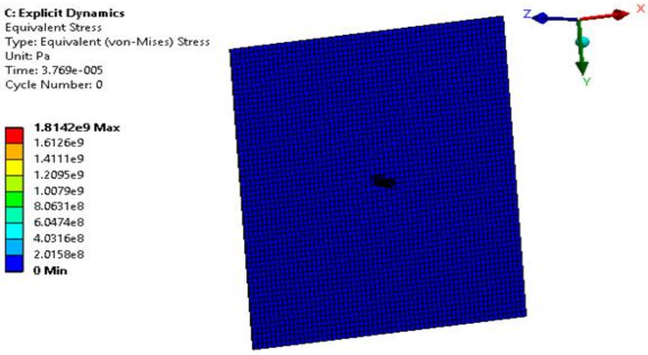
Equivalent stress of the bullet at which it deforms by impact on the composite material (Kevlar 49, Kevlar29, Kevlar149) value are 1818.5MPa, 1839.3MPa, 1814.2MPa as shown in fig.5.23, 5.24, 5.25 by using explicit analysis for Kevlar material.



Equivalent Stress (Kevlar49)

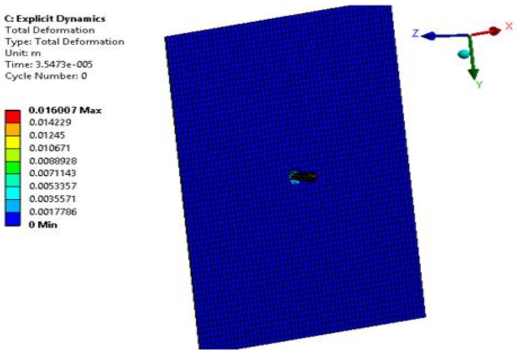


Equivalent Stress (Kevlar29)

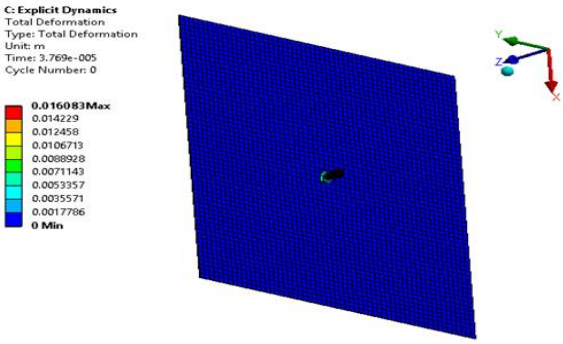


Equivalent Stress (Kevlar149)

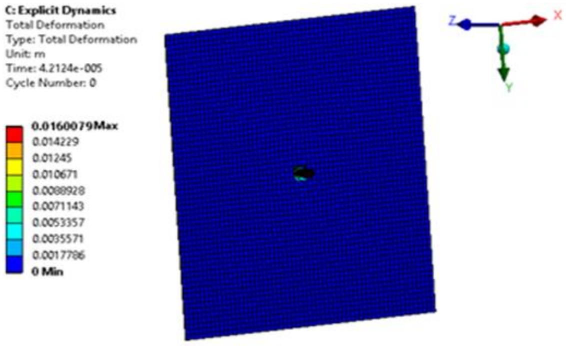
Total deformation of the bullet at which it deforms by impact on the composite material (Kevlar 49, Kevlar29, Kevlar149) value are 0.016007m, 0.016083m, 0.016007m as shown in fig.5.20, by using explicit analysis for Kevlar material.



Total Deformation (Kevlar49)



Total Deformation (Kevlar29)



Total Deformation (Kevlar149)

ISSN (O) 2393-8021, ISSN (P) 2394-1588

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