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Numerical Investigation And Simulation of Impact Energy Absorption by Materials in Ballstic

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***Abstract*— This report treats terminal ballistics which is the branch of the ballistic science concerning the mechanics of impact. The purpose of this project is to determine the parameters governing projectile failure when impact against a target is achieved and energy loss of projectile in each layer of composite are observed. In the Simulation approach, a model has been derived capable of determining the amount of deformation in the projectile after impact, energy summary in each layer An Simulation method of obtaining the resistance pressure, by which the target resists penetration, and a method of determining the energy loss project tile material are also implemented. A numerical section explaining the main factors and approaches in hydro code and dynamic modeling is also devised along with simulations of projectile impact.**

Keywords*— *Ballistics, Projectile and target, Penetration Depth, Projectile failure

I. INTRODUCTION

In ballistics the protection from the targeted projectile requires loss of energy or absorption of energy of projectile by protected material. Today modern projectiles are more advanced, powerful, high velocity and high energy objects which can damage the targeted object in seconds. To protect the object from the powerful projectile we require strong and highly advanced material on the surface which can cover the whole body of the object. Modern defense system associated with advanced technology in material science which can be used to selection of materials for design the system.

Material selection plays vital role in the design of any system. Material selection is depend on the type of the object, where can be used and how it can be used. Surrounding systems around the object effect on the object material and it can be leads decreases the life span the object. In Advanced systems most of the materials used are combination materials like alloys and composites. Materials posses different properties based on the conditions it can also effect the system.

II. MATERIALS AND METHODS

Materials requires for system is the important decision for the design. Materials for ballistics requires highly strength and hard. Composites and alloys are widely used for design process. For strong materials can posses high density, low weight, high hardness etc. energy absorption of materials require high density, fracture toughness and strength. Fracture toughness is the important property for absorption of energy. Fracture toughness is determined by impact test.

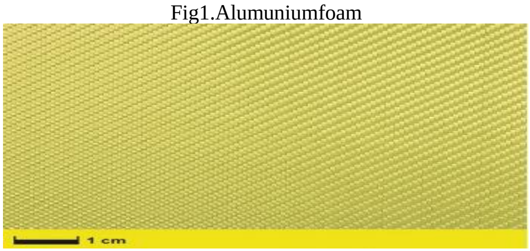
In modern system considering all the conditions we require high density, fracture toughness, high stiffness, low density and highly ductile material. Aluminum foam and Kevlar are tested for this purpose.

Table1. Properties of materials

S. No	Layers of armour plate	Density (Kg/m^3)	Young's modulus (GPa)	Poisson ratio	Yield stress (GPa	Specific heat (J/Kg k)
1	Kevlar	1440	91	0.3	217	710
2	Aluminium foam	700	100	0.33	140	950

Kevlar poses good absorption of energy property, chemically inactive, low thermal conductivity properties. It has high resistance to stop object and it can leads loss of energy in the object which may decrease the damage of system. Aluminum foam is highly ductile and low weight. It can decreases velocity of the object. These two materials are used in ballistic protection system as hybrid composite.

Fig1.Alumuniumfoam



. Fig 2.kevlar layer

III. NUMERICAL CACULATION

Energy absorption by the layer = (fracture toughness of the material x area of penetration by bullet) / √ (thickness of the layer penetrated by the bullet)

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$$E = \frac{F.T \times A \times L}{\sqrt{t}}$$

F = Fracture toughness of the layer

Ea = Absorption energy by layer

A = Area of cross section of bullet

L =Distance between target and observer

t = Thickness of layer

Total energy = Absorption energy by the Kevlar . + remaining energy

Remaining energy = Force on the second layer

Absorption energy by the layer = kinetic energy absorbed

Absorption energy $= \frac{1}{2} M (V_i^2 - V_r^2)$

V_r = Residual velocity of projectile

V_i = Intial velocity of projectile

Energy at the present at the surface layer by bullet. . $= \frac{1}{2} MV_e$

M = Mass of the projectile

V_e= velocity present at the surface . .

In numerical calculation energies and velocities are determined. Energy absorption in the material is appoximated by the given formula. The mass of the bullet taken as 10 grams. The velocity attain by the bullet from the gun barrel taken as 854m/s.

The residual velocity of the bullet calculated by the theoretical formulation. Thickness of the layers of material is varied and absorption energies are calculated. The distance between the targeted object and gun barrel taken as one metre and it is taken as length in the formula. Fracture toughness is the material property used in the formula and other values are depends on geometry and velocity.

IV. DESIGN AND SIMULATION

Kevlar layer**:**

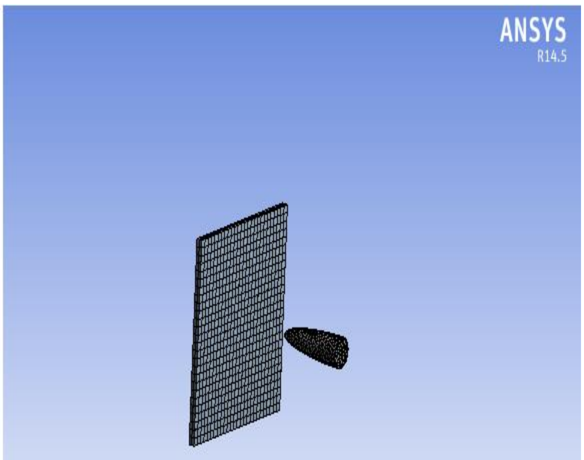

Fig 3. kevlar layer meshing

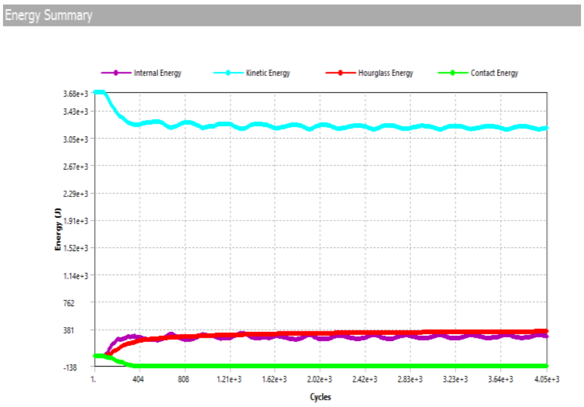

Fig 4.2 mm thickness Energy absorption

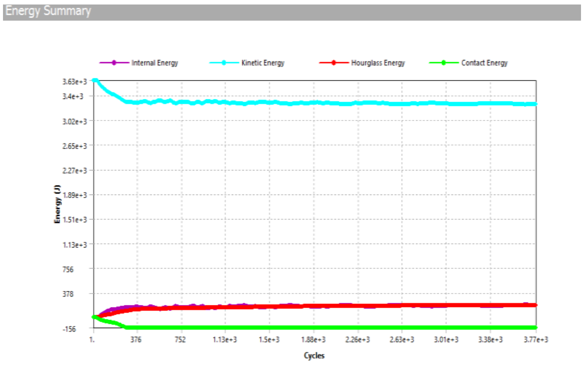

Fig 5.4 mm thickness Energy absorption

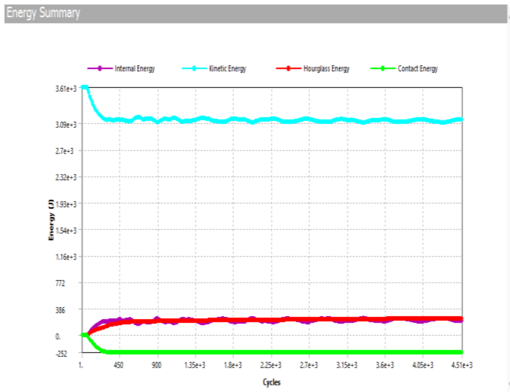

Fig 6.6 mm thickness Energy absorption

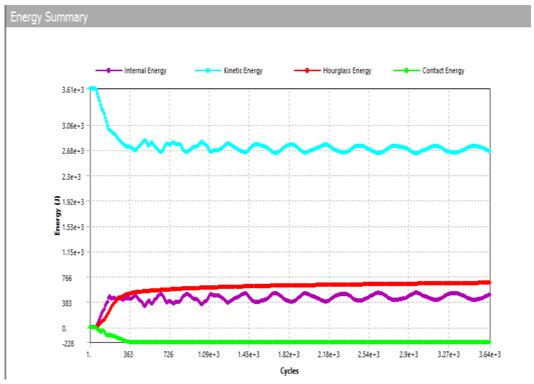

Fig 7.8 mm thickness Energy absorption

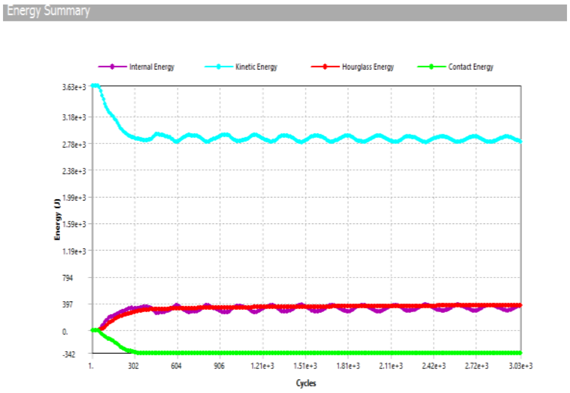

Fig 8.10 mm thickness Energy absorption

Aluminum foam**:**

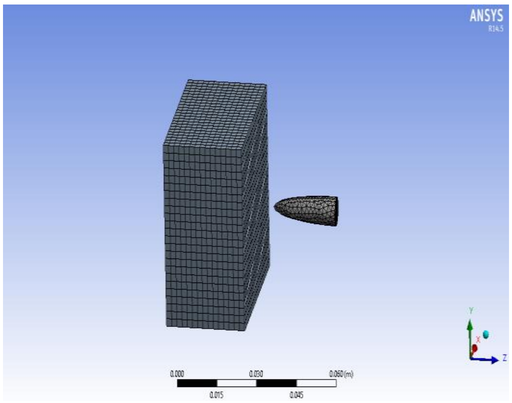

Fig 9.2 mm thickness

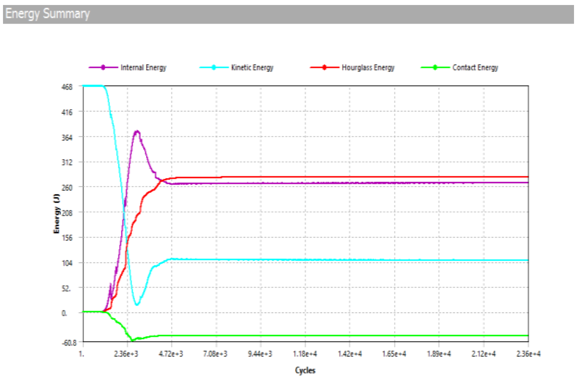

Fig 10.30 mm thickness Energy absorption

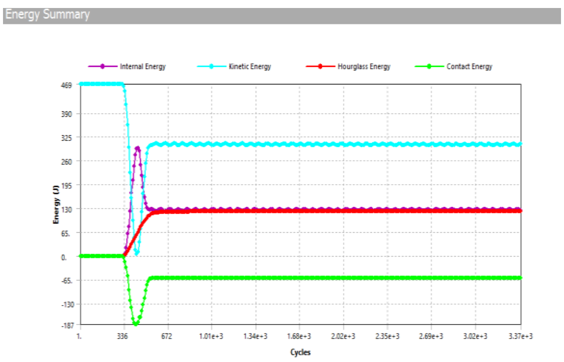

Fig 11.28 mm thickness Energy absorption

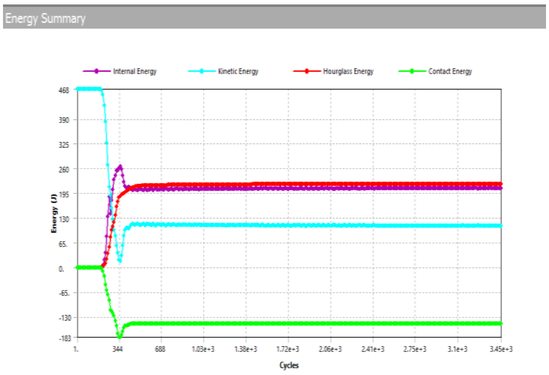

Fig 12.26 mm thickness Energy absorption

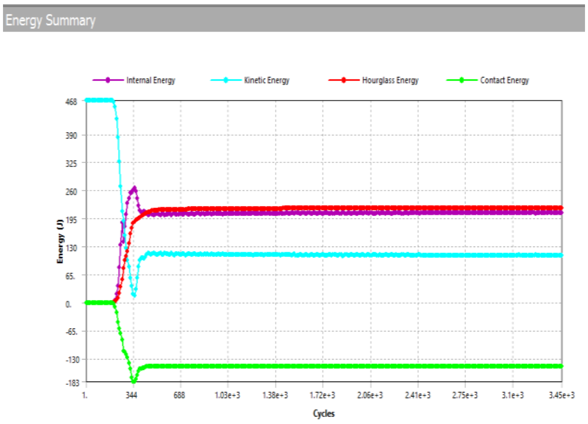

Fig 13.24 mm thickness Energy absorption

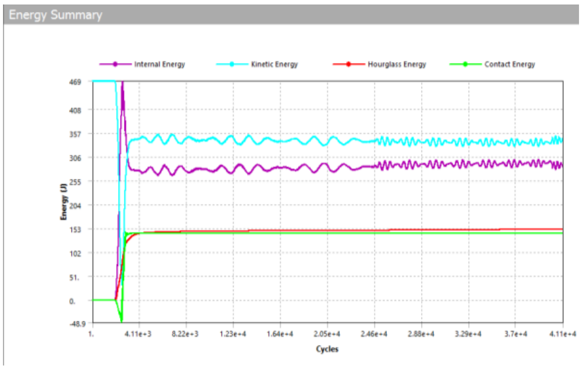

Fig 14.22 mm thickness Energy absorption

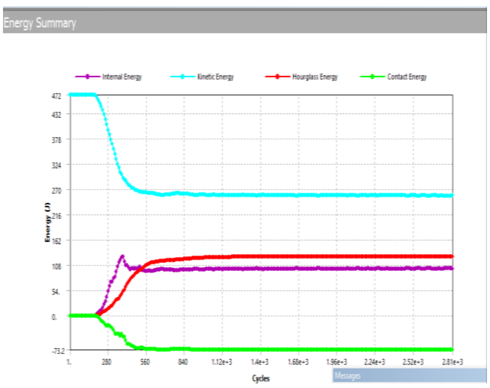

Fig 15.15 mm thickness Energy absorption

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V. RESULTS AND DISCUSION

Energy absorption of material determined by numerical investigation and simulation methods. In numerical method fracture toughness is the important property for calculations. Energy absorption is varies by thickness of layer and increasing the layer thickness increases the loss of energy of the projectile. In numerical and simulation methods we also calculate velocities of the projectile which is used calculate energies.

For simulation method we are used LS AutoDyna in ansys workbench. Initial conditions, boundary conditions plat predominant role to get exact values.

Energy absorption of material increases the thickness of the material but it leads increases the thickness and weight of the system. Considering the conditions we optimize the thickness and weight, it leads increases the efficiency of the system performance.

Table2. Kevlar energy absorption at various thickness

S no	Layer thickness (mm)	Energy loss (Joules)	Velocity reduction(m/s)
1	2	251	29.3
2	4	370	45.1
3	6	585	72.3
4	8	710	88.6
5	10	861	109.2
6	15	945	120.5

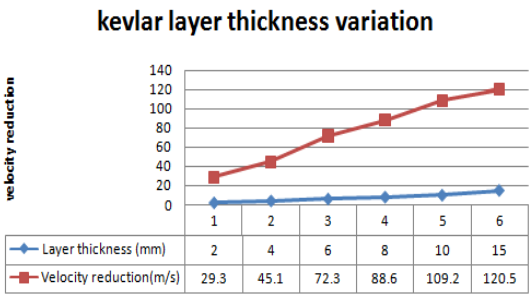

Fig 16. Thickness vs Velocity

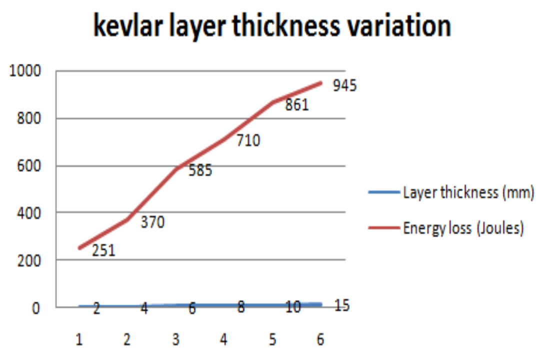

Fig 17. Thickness vs Energy absorption

Table 3. Aluminum foam energy absorption at various thickness

S no	Layer thickness (mm)	Energy loss (Joules)	Velocity reduction(m/s)
1	30	469	306.3
2	28	442	297.1
3	26	418	289.2
4	24	386	278.5
5	22	352	265.2
6	15	258	227.6

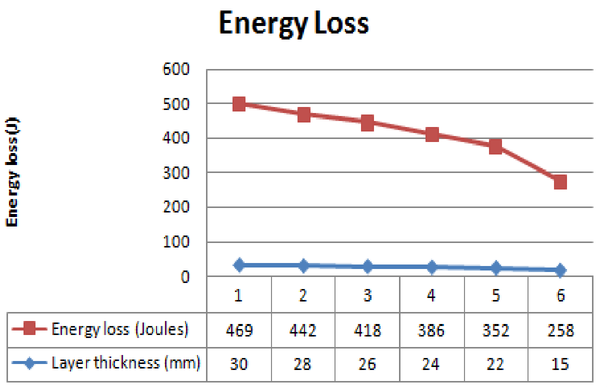

Fig 18. Thickness vs Velocity

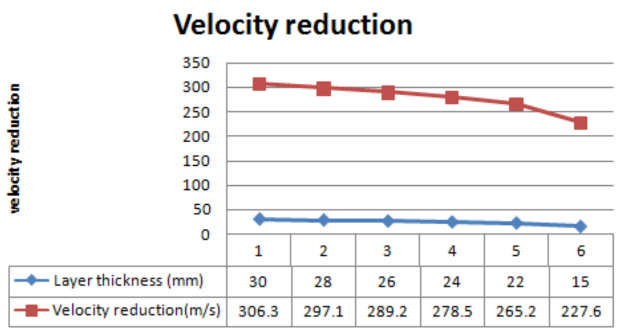

Fig 19. Thickness vs Energy absorption

VI. CONCLUSION

This is aims towards better efficiency of material layers and also identifies the optimum thickness of layers which also effect on weight reduction of ballastic armour. Efficiency of performance is maximum at optimal conditions. Kevlar and aluminum foam are the materials used for ballistic protection system. High density, stiffness, elastic strength, high ductility, fracture toughness are the properties considering for design process.

Considering all the results of the materials we can conclude that aluminum foam, Kevlar are suitable ballstic protection system. They can resist the high projectile efficiently.

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