UNIVERSITY OF DELAWARE

MODELING THE ROLE OF FRICTION DURING BALLISTIC IMPACT OF HIGH-STRENGTH PLAIN-WOVEN FABRIC

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INTRODUCTION AND OBJECTIVE

High-strength plain-woven fabrics are often used in flexible ballistic impact protection systems

- Bulletproof vests
- Turbine engine fragment barriers

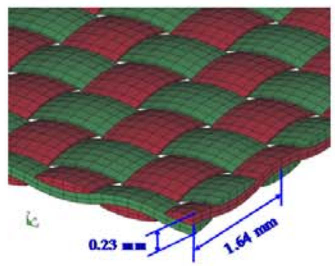
The energy absorption characteristic of a fabric system under ballistic impact is affected by a number of factors

- Material property of the constituent fibers and fabric weave style
- Number of fabric layers and areal density
- Projectile and impact parameters
- Interfacial friction within the impact system

Elucidate the role of interfacial friction during ballistic impact of high-strength plain-woven fabrics

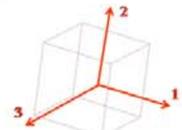
- The problem is hard to resolve through experimentation only
- Develop a three dimensional finite element analysis (FEA) model
- Simulate the ballistic impact of a patch of fabric using LS-DYNA
- Comparatively investigate the role of friction (yarn-yarn, projectile-fabric) during the ballistic impact

FEA MODEL AND YARN MATERIAL PROPERTY



Maximum von-Mises stress failure criterion

$\bar{\sigma}_{max} = 130\,\text{GPa}$



Locally orthotropic elastic material (GPa)

E_{11}	E_{22}	E_{33}	G_{12}	G_{13}	G_{23}	ν_{12}	ν_{13}	ν_{23}
164	3.28	3.28	3.28	3.28	3.28	0	0	0

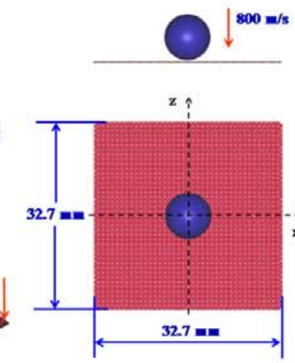
BALLISTIC IMPACT OF A SQUARE PATCH OF FABRIC

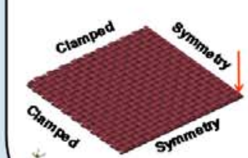
The fabric edges are perpendicular to the warp/weft yarns

Diameter of the rigid sphere: 8 mm

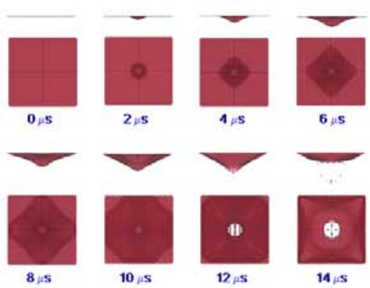
Mass of the rigid sphere: 2.091 g

Density of the yarn material: 600 kg/m^3



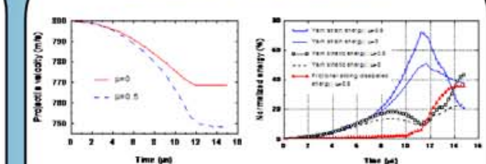


DEFORMED FABRIC CONFIGURATIONS



Friction coefficient μ=0.5

ENERGY TRANSFER



$E = \frac{1}{2} m (v_i^2 - v_r^2)$

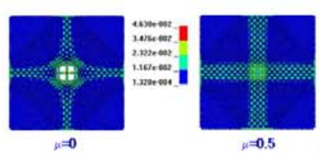
where,

E - fabric energy absorption capacity

m - mass of projectile

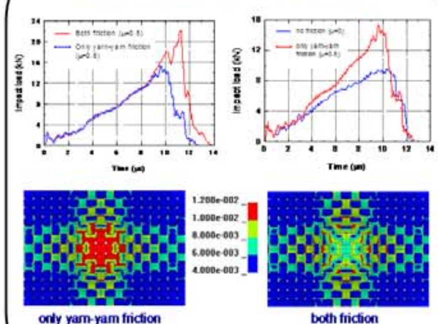
v_i - impact velocity

v_r - residual velocity



Fabric von Mises stress distributions at 9 μs

THE ROLE OF FRICTION



Fabric von Mises stress distributions at 5 μs

CONCLUSIONS

1. Friction hinders the lateral motion of principal yarns and requires the spherical projectile to load and break more yarns
2. Friction contributes to fabric energy absorption not only through frictional sliding dissipated energy but also by increasing yarn strain energy and yarn kinetic energy
3. Friction between projectile and fabric delays yarn breakage by distributing the maximum stress along the periphery of projectile-fabric contact zone and substantially increases fabric energy absorption in later stages of impact event
4. Friction between yarns at crossovers resists relative motion between yarns and induces yarn to break at an earlier time

ACKNOWLEDGEMENTS

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