EFFECT OF SUB-LAMINATE STACKING SEQUENCE ON THE TRANSVERSE IMPACT AND PERFORATION BEHAVIOR OF MULTI-LAYER SOFT-BODY ARMOR PACK (SBAP)

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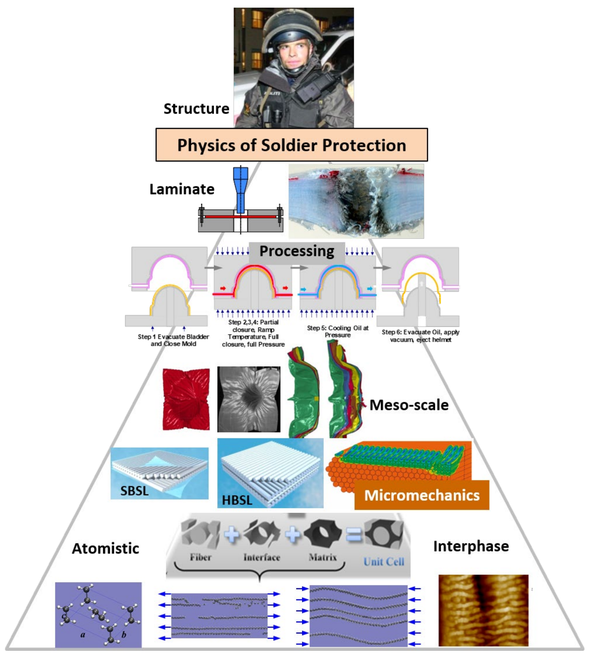
Introduction

- SBAPs are components in body armor and are composed of Dyneema SK76, [0/90] soft ballistic sub-laminates (SBSL)
- Orientation of SBSL has an affect on the performance of the SBAP

Objectives

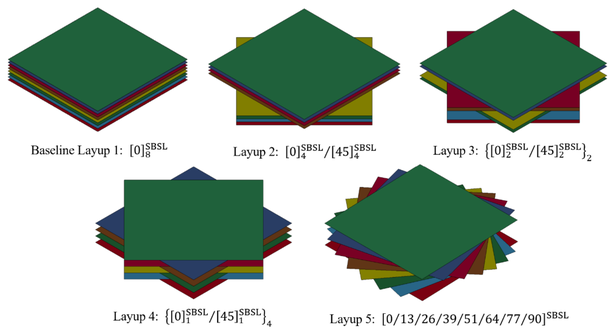
- Compare the minimum perforation velocity of different stacking sequences of an 8-Layer SBAP
- Explore the affect of the stacking sequence on the deformation cone shape of the 8-Layer SBAP

Structural Hierarchy of Materials by Design for Soldier Protection



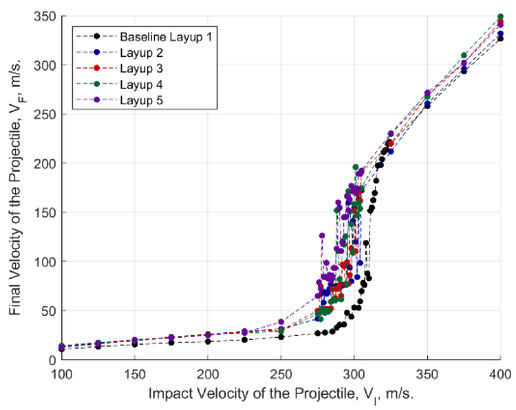
Stacking Sequences

- Model a 360mm x 360mm 8-Layer SBAP with five different stacking sequences (Layups)
- Denoting a single layer [0/90] SBSL as $[\beta]^{SBSL}$ (where β is the material angle of [0/90] SBSL with respect to reference material direction 1 or [0])



Perforation Mechanics

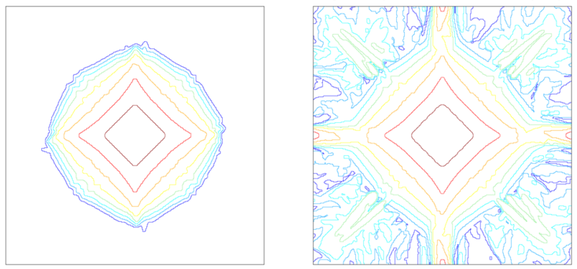
- Simulated impact velocities ranging from 100 m/s to 400 m/s under a right circular cylinder impactor with a diameter of 12.7 mm
- Plot final velocity (V_F) vs impact velocity (V_I) to determine minimum perforation velocity



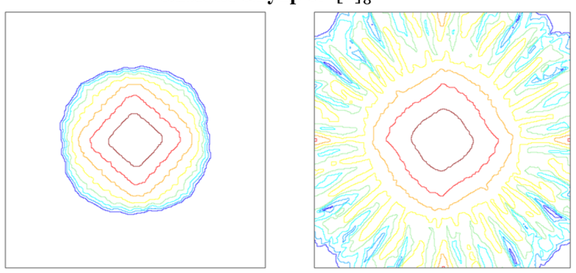
- The V_F - V_I curve for each layup can be divided into three regions
  1. No Perforation: initial linear trend
  2. Partial Perforation: nonlinear deviation from initial linear trend
  3. Complete Perforation: jump in V_F

Deformation Mechanics

- Deformation cone shape is given by back face deflection
- Back face deflection causes blunt force trauma to the wearer



Baseline Layup 1: $[0]_8^{SBSL}$



Layup 5: $[0/13/26/39/51/64/77/90]^{SBSL}$

- Back face deflection over time, dark red = 0ms and dark blue = 8ms
- On impact layer, deformation cone begins as a diamond and becomes circular
- Rear/back face shows “spokes”, four for each unique material angle

Summary and Conclusion

- Baseline Layup 1 $[0]_8^{SBSL}$ has the highest minimum perforation velocity range
- The effect of the stacking sequence on the shape of the deformation cone is present on the rear/back face

Future Work

- Perform the same study on a 32-Layer SBAP to see if results are consistent at different layer counts
- Perform a similar study looking at the interlaminar stacking sequence of the SBSL

References

- B. Z. Haque, M. A. Ali, and J. W. Gillespie, “Modeling transverse impact on UHMWPE soft ballistic sub-laminate”
- B. Z. Haque and J. W. Gillespie, “Perforation mechanics of UHMWPE soft ballistic sub-laminate and soft ballistic armor pack: A finite element study”

Acknowledgements

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