Lessons from the Defence Sector for Commercial Composites Applications

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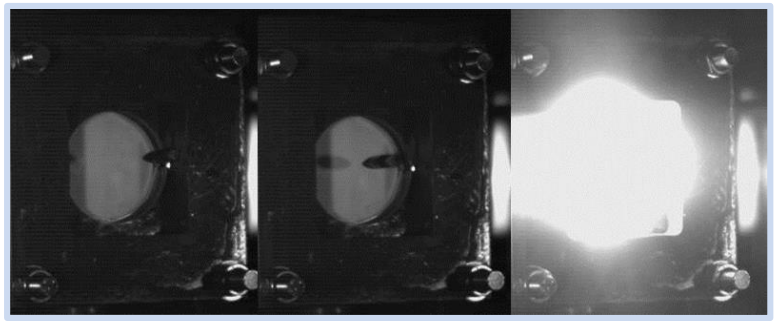
Morgan Advanced Materials
30 years Composite Components Design and Production Expertise

Multiple Materials

Glass Fibre
Carbon Fibre
Aramids
PP
UHMWPE
Ceramics
(SiC, Al_2O_3, B_4C)



Multiple Resin Systems

Thermosets:
Epoxies
Phenolics

Thermoplastics:
P.U.

Multiple Processes

In Autoclave
Out of Autoclave
Compression Moulding
Injection Moulding

Ballistic Protection for Defence

Key Requirements:

- Protection against
  - Bullets
  - High Velocity Fragments
  - Shock Waves
- Minimum Weight
- High Integrity
- Structural Performance (Vehicles & Helmets)

Ballistic Impacts are High Strain Rate Events

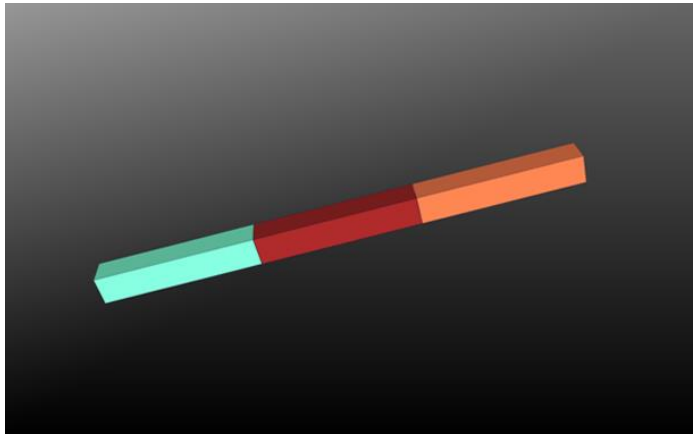
Morgan has developed deep expertise in the behaviour composite materials and constructions under extremely high strain rate impacts:

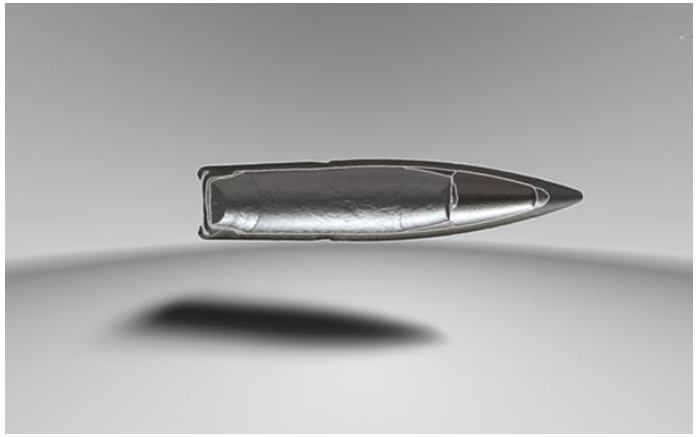
- Decades of practical experimentation
- Through field experience
- Capture by ultra-high speed cameras
- Morgan has now developed bespoke computer models and correlated them with observed results.

Predicting Behaviour of Ceramic/ Composite Structures Under Impact

Prediction of the behaviour of ceramic faced, complex composite structures subjected to ballistic impacts

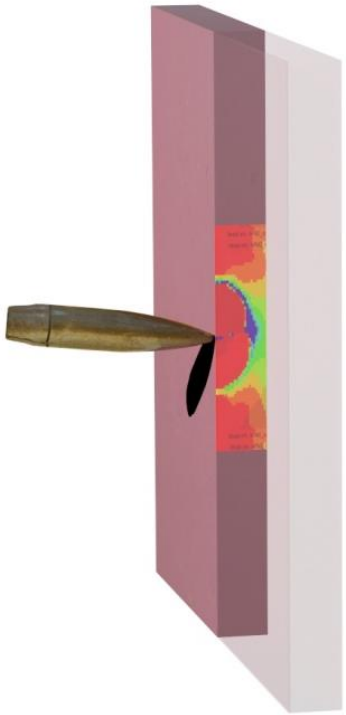
- Approach:
  - Build up assembly construction layer by layer
  - Generate computer model of the test procedure
  - Refine test
  - Model the expected material behaviour in the test
  - Perform tests and observe results
  - Refine computer models
- Inputs:
  - Failure mode: examine samples post test
  - Analysis of high speed video
  - Threat analysis and modelling
- Other model inputs:
  - Fundamental material performance measurements at low and high strain rates





Benefits of Computer Modelling

- Fundamental understanding of design factors influencing armour performance
- Identification of key parameters to measure for new armour materials and impact threats
- Reduced future development costs; only test designs to validate model outcomes
- Improved armour and composite constructions
- Ceramic core optimisation in Body Armours



Predicting the Fatigue Life of Composites - Building Confidence for New Adopters

Vehicle Defence Customers are:

Familiar and comfortable with steel armours

Recognise that composites offer substantial weight savings

But suspicious of composites' performance degradation over time

Morgan Produced the First Composite Armoured Vehicles 25 Years Ago.

- We have tested ballistic performance of 20 year old, combat used, vehicles and compared it with original performance
- This data shows very little degradation.
- The data has been used to determine parameters for fatigue models and enabled us to predict performance of new vehicles
- This is vitally important for persuading military customers who are accustomed to FEA

Case Study
Design and Development of Combat Helmet

Combat Helmet Case Study
Morgan Solution

Latest UHMWPE – Thermoplastic Materials

- Substantial improvement in ballistic and fragment protection over aramids.
- 35% lower weight

But:

- Lower stiffness therefore poorer structural performance than aramids (Thermoset)
- Poorer flame resistance
- Higher cost

Morgan Technical Solution:

- a hybrid structure of: UHMWPE, aramids and carbon fibre
- in a single component structure

Other Applications and Conclusions

Protection for Safety Critical Systems:

- Li-Ion Batteries in Cars or other products
- Fuel Tanks in cars
- Impact structures for satellites
- Impact structures for rail

From practical experience we have developed specific computer modelling techniques for high strain rate impacts and the fatigue life of stressed composite structures.

This knowledge has the potential to be applied to the wider commercial composites world.

Lessons from the Defence Sector for Commercial Composites Applications

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