The use of Finite Element Analysis in the Design of a Lightweight Cartridge Case

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TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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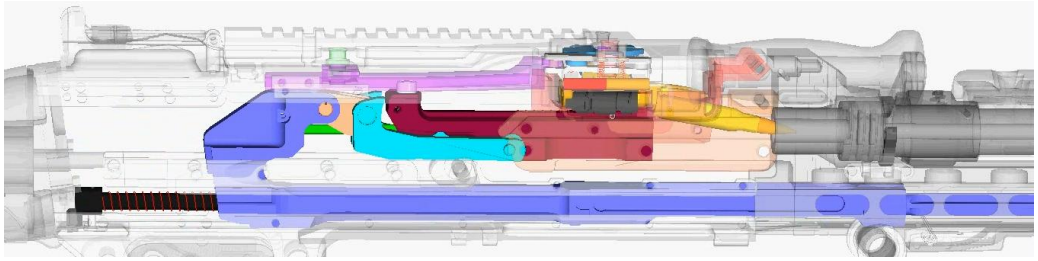
Lightweight Case Overview

- We've been using brass for a long time
  - Brass has both high strength and ductility
  - Unfortunately while brass has ideal material properties for a cartridge case it's a dense material

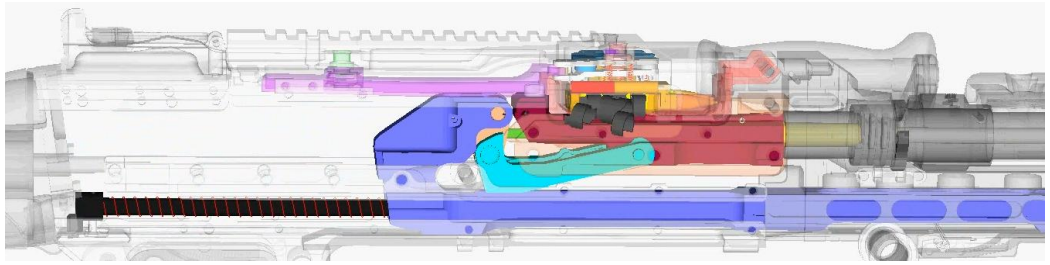
- Other materials have been researched
  - Steels - either to soft or to hard
  - Aluminums – burn through failures
  - Polymers – to weak in unsupported region
    - Most new designs have steel or brass bases with polymer front section
    - Still have problems with base separation

Gun Cycles

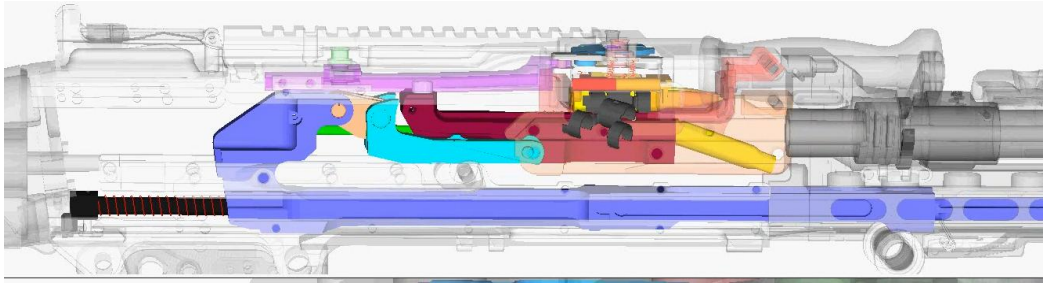
Feed



Pressurization

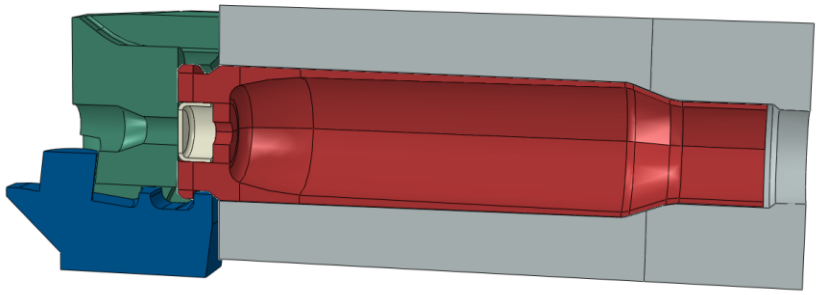


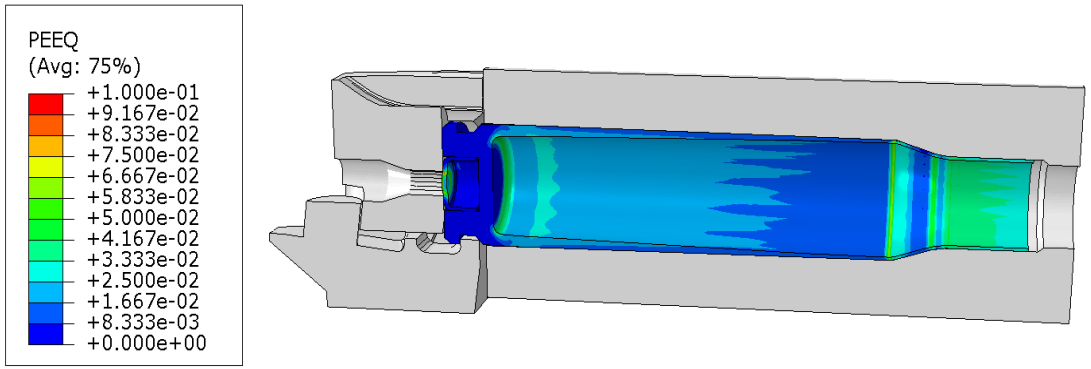
Extraction



Why use Finite Element Analysis (FEA)

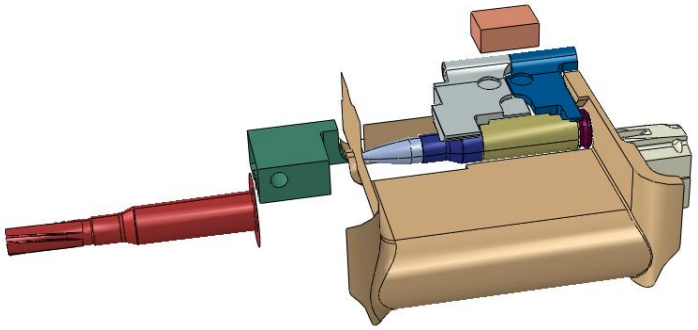
- FEA allows for the visualization of phenomena that can't be seen in live fire testing
- With accurate material models FEA can predict failures and what stage of the firing process they occur in

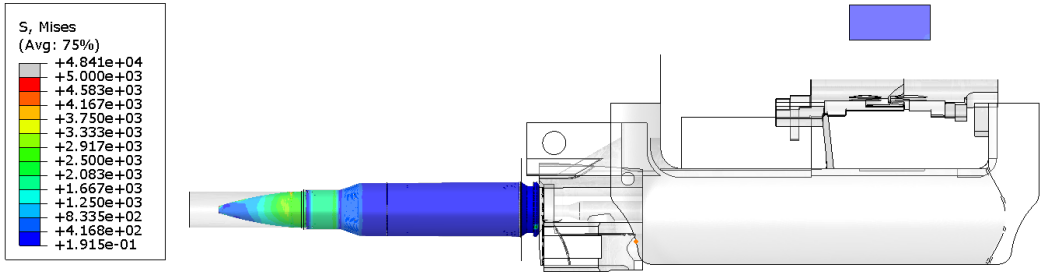




Feed Models

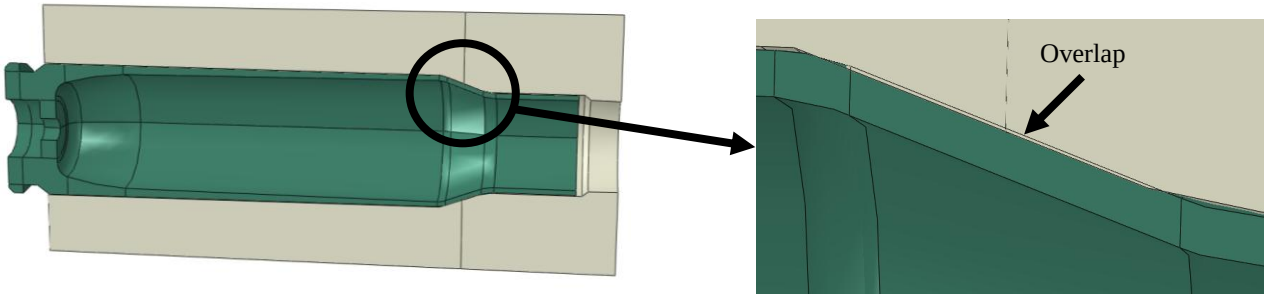
- Full feed model encompassed the entire length of bolt travel
- Occurs over a long time period so very computationally expensive
- Results showed minimal stress occurs in bullet and round due to feeding process.
- Most stress occurs in the cartridge case due to the crush condition from headspacing.

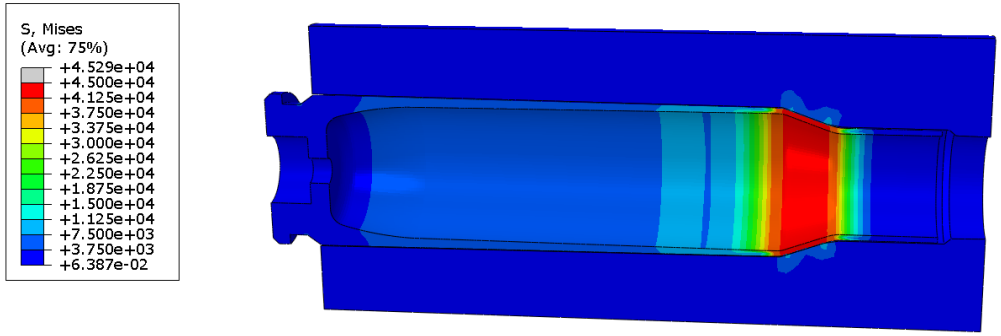




Simplified Feed Model

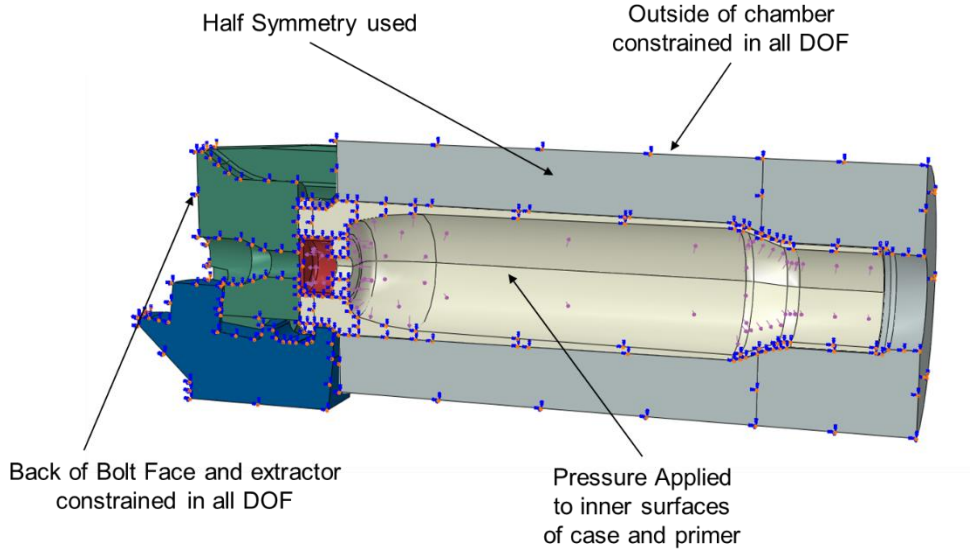
- Feed model could be simplified into a basic press fit model
- Still captures the initial stress due to the crush condition
- Model run time goes from days to minutes



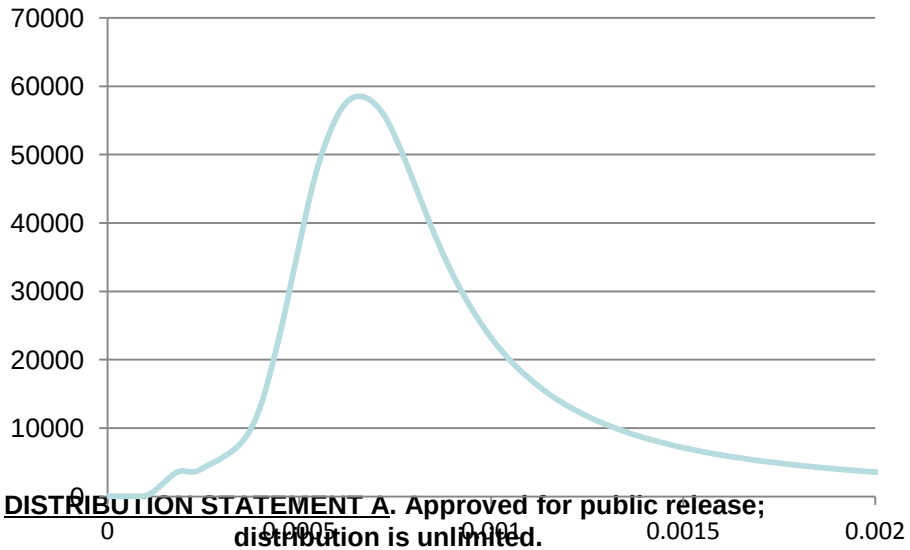


Pressurization Model

- Captures the pressurization event
- Press fit results are imported at beginning of the model

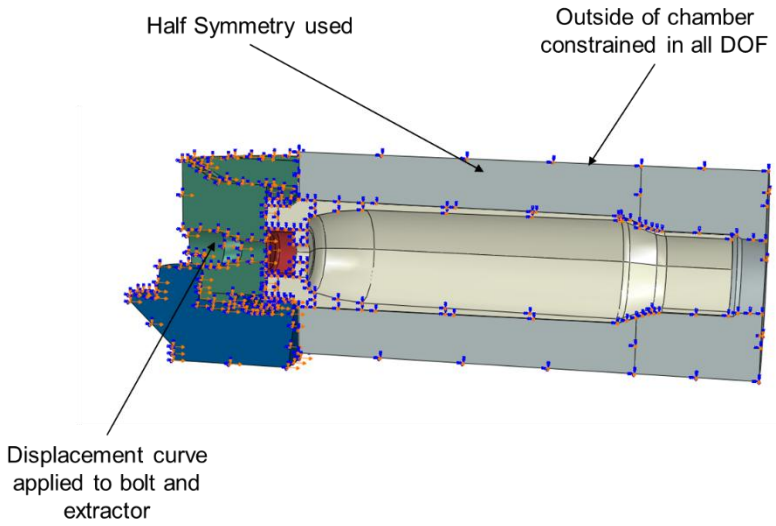


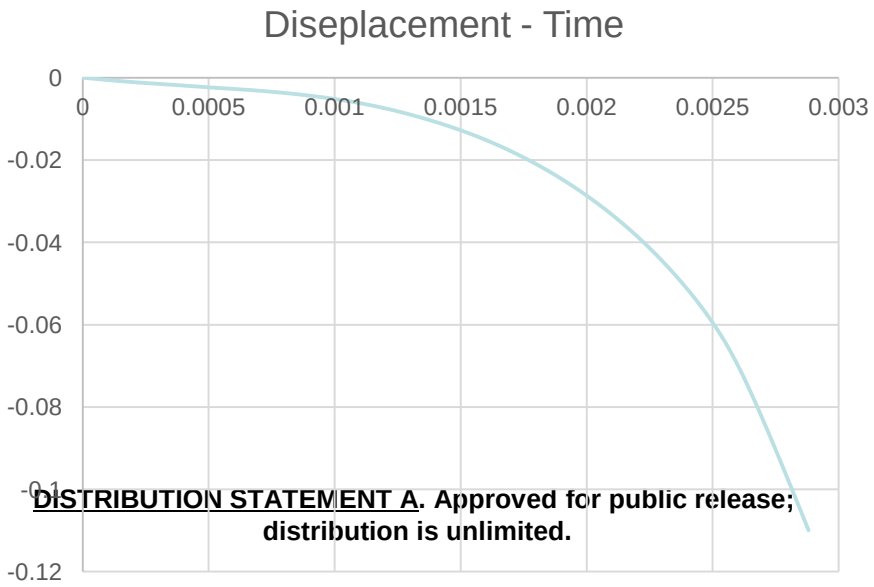
Pressure Time Curve



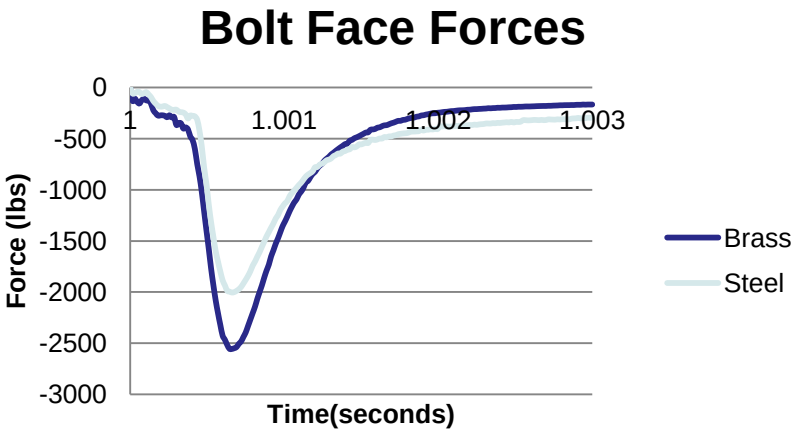
Extraction Model

- Captures the extraction event
- Pressurization results are imported at beginning of the model

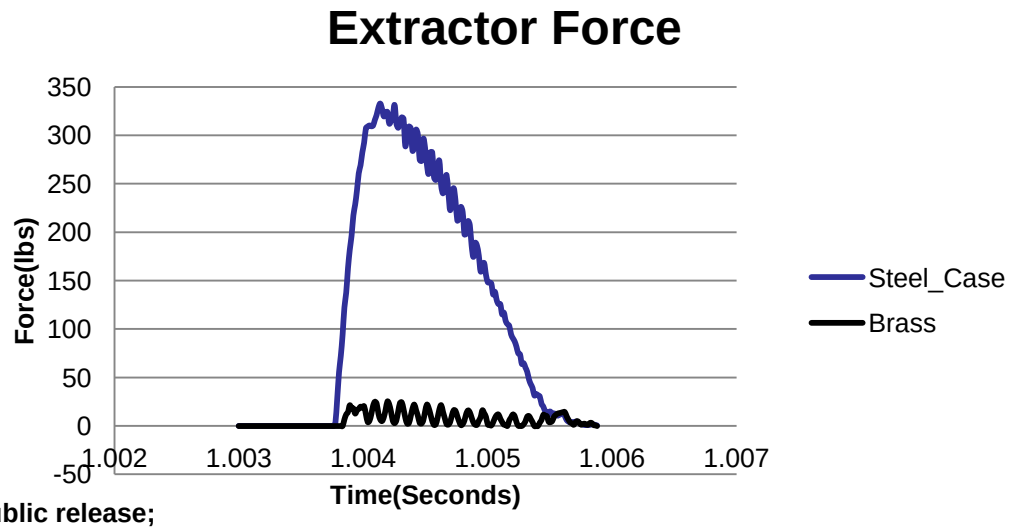




Comparing Brass and Steel

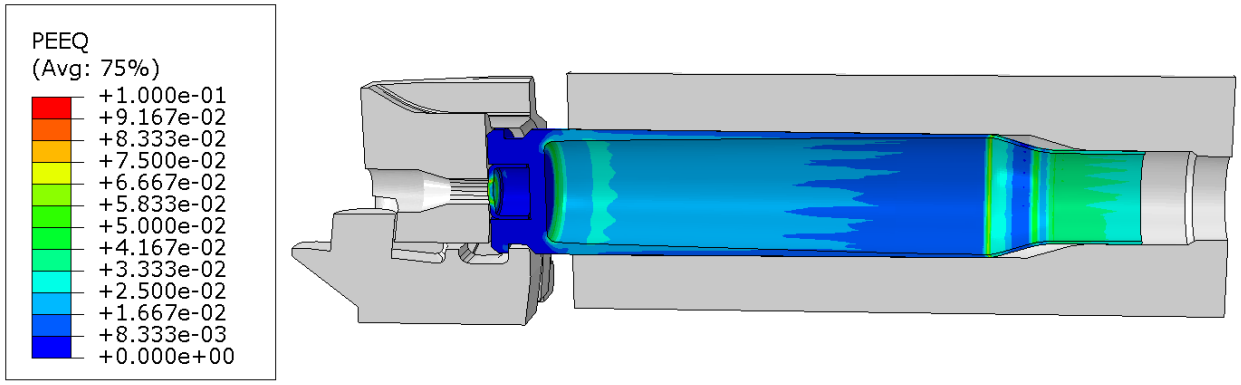


- Steel has a high modulus of elasticity when compared with brass
- Less expansion axially during pressurization
- Less elastic recovery radially during expansion

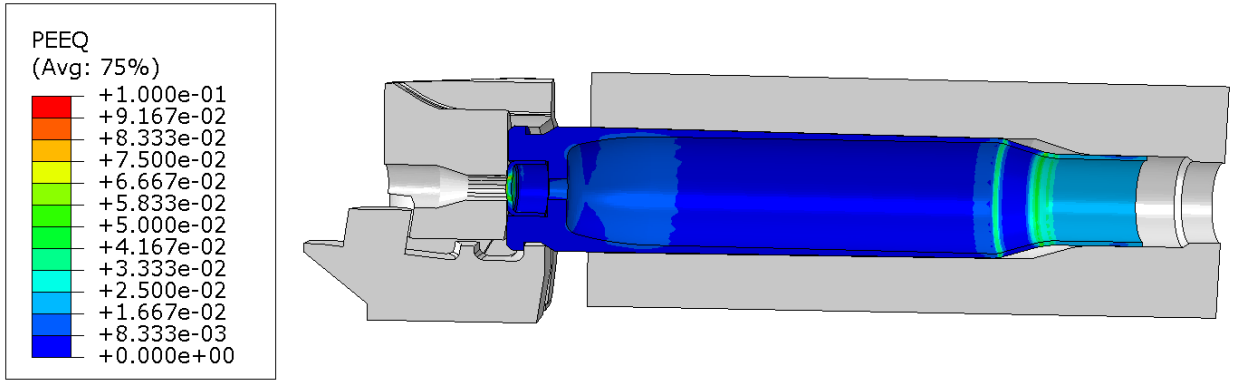


Comparing Brass and Steel

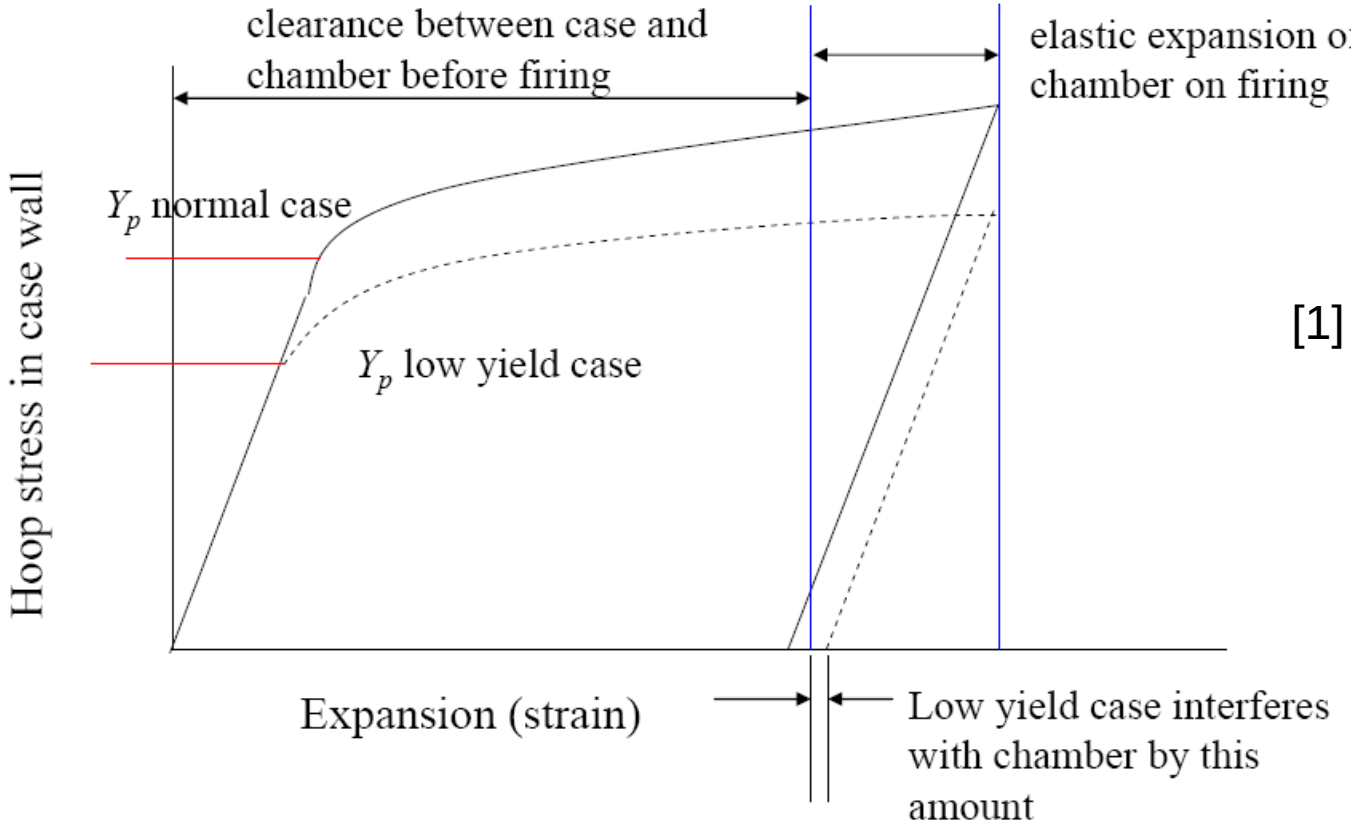
Steel Case Plastic Strain



Brass Case Plastic Strain



Extraction Design Considerations



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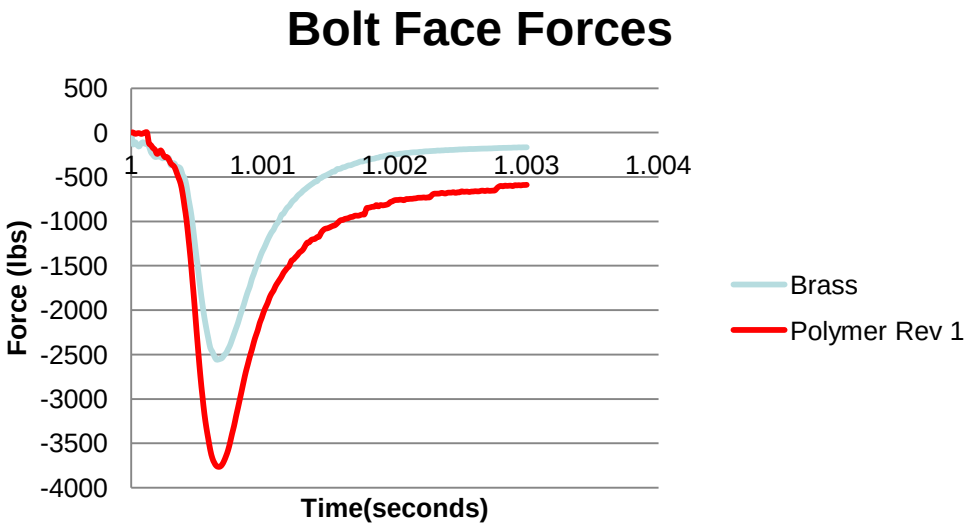
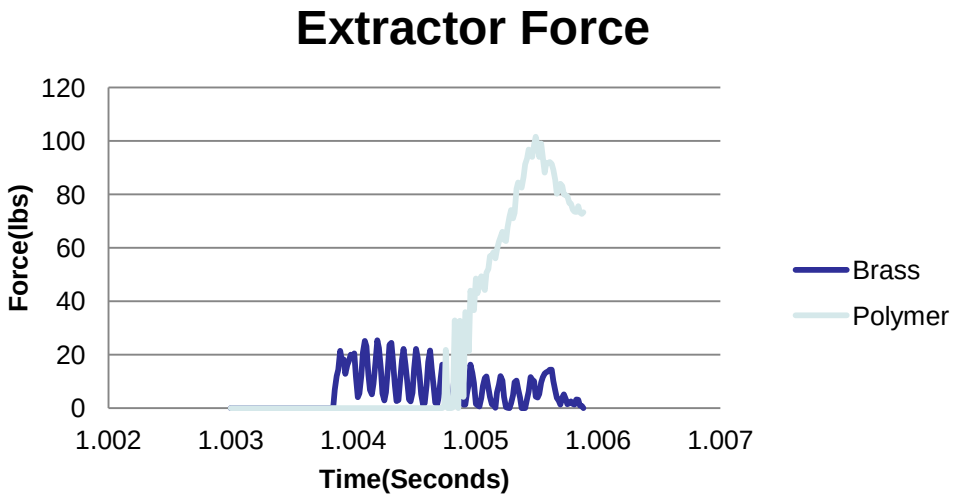
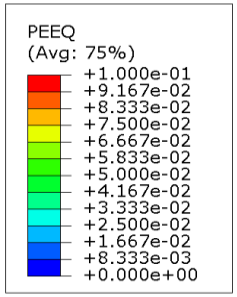
Polymer Case compared with Brass

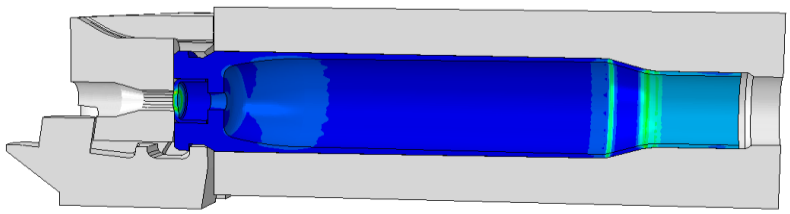


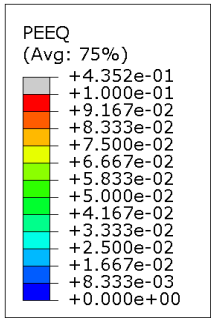
- Chosen polymer has much lower modulus of elasticity when compared with brass
- More axial expansion means much higher bolt face forces
- High extraction forces due to base separation issues

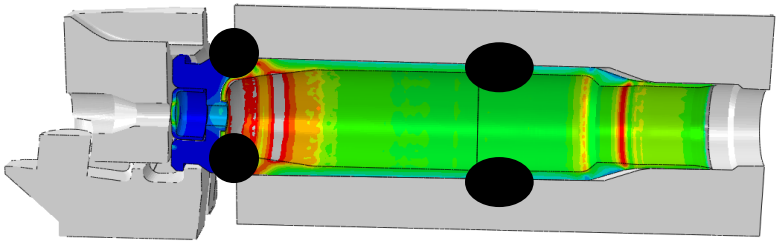


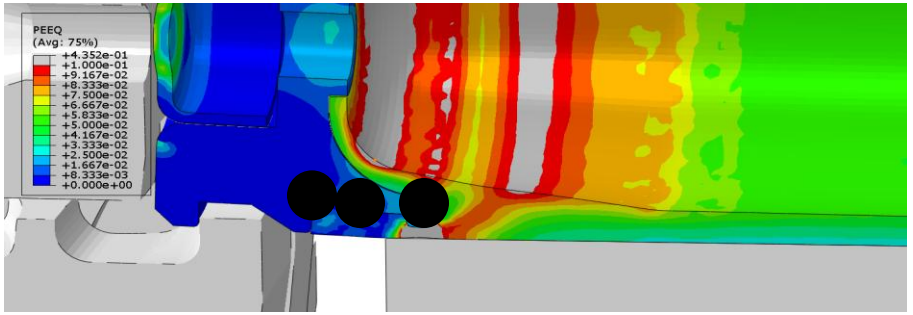
Comparing Polymer and Brass





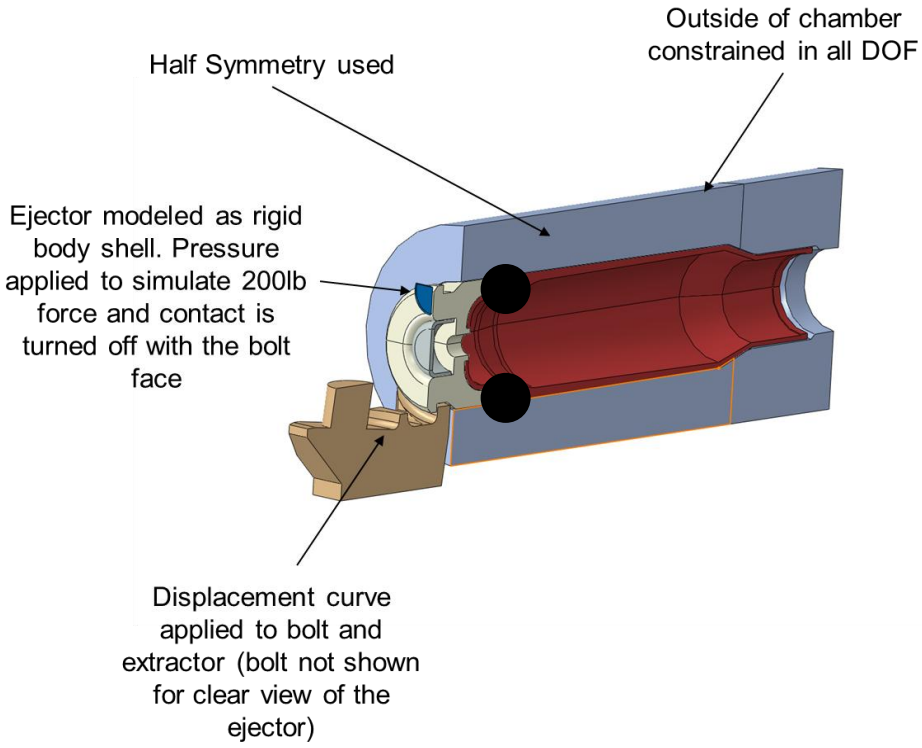






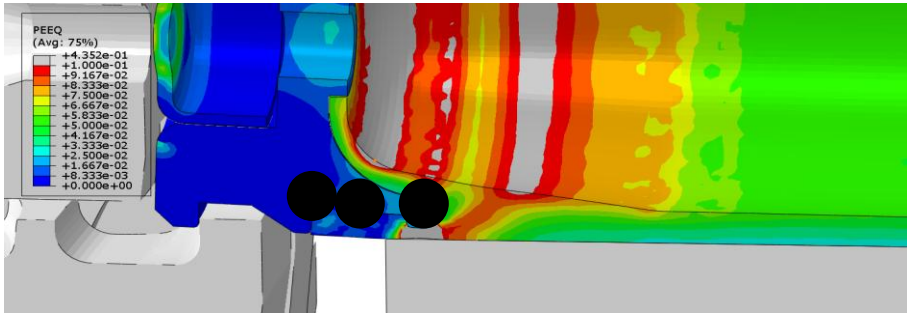
Addition of the Extractor

- Extractor adds to the torqueing effect seen during extraction

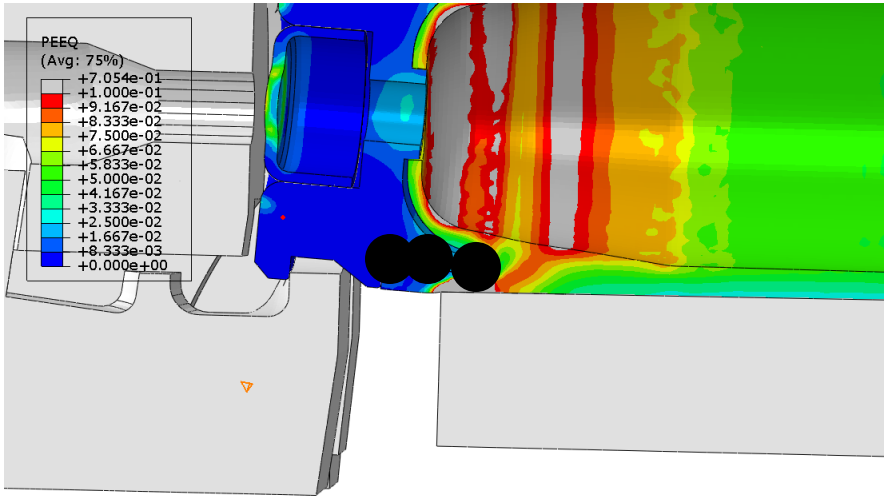


Polymer Comparison with the Ejector

No Ejector



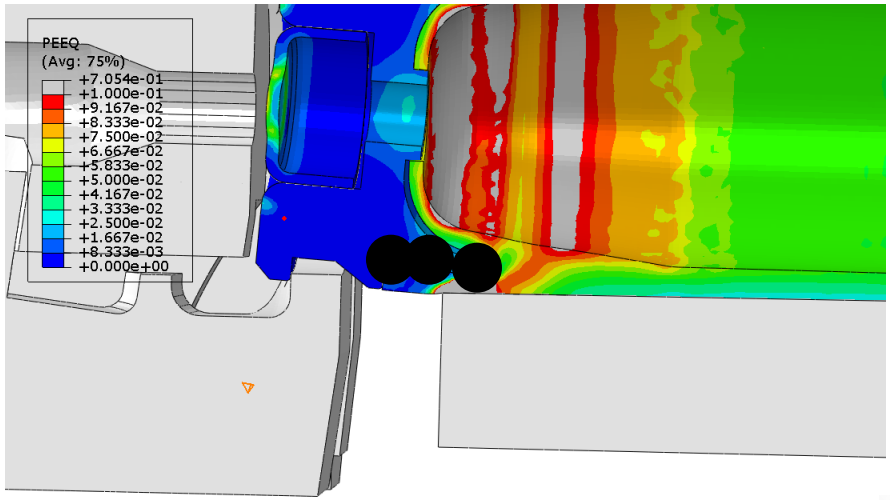
With Ejector



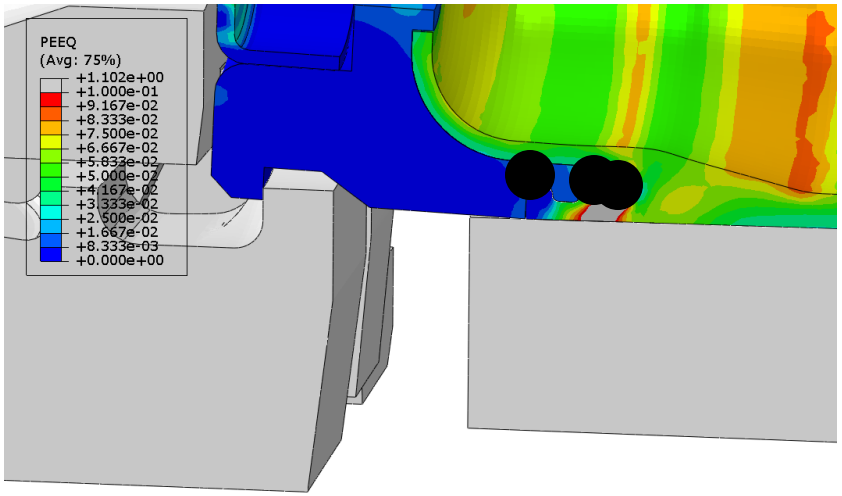
Adding ejector increases plastic strain in the hot spot from ~40% to ~70%

Polymer Comparison updated geometry

Rev1 With Ejector



Rev3 With Ejector



Optimizing steel insert length reduced plastic strain in hot spot to ~37% with ejector

Summary/Future Work

- FEA is able to show how material properties of cartridge cases can affect interaction with the weapon system interface
- FEA was also able to accurately predict cartridge case failures and geometry changes that would mitigate weak points
- Future work should focus on high strength polymer materials research
- Weapon systems should also be evaluated for changes that could lead to polymer case success

Questions

References

- [1] Carlucci D., Jacobson S., (2008). Theory and Design of Guns and Ammunition. NY: CRC Press