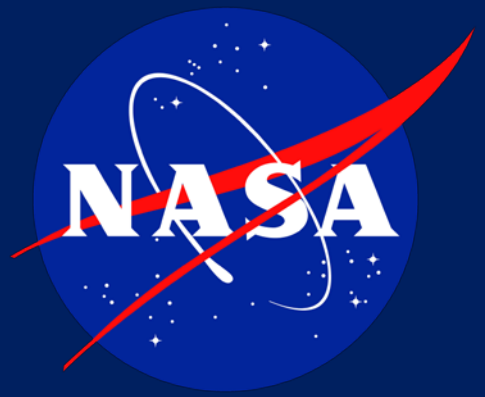

JACOBS™

EVALUATION OF CYCLO OLEFIN POLYMER AS SABOT MATERIAL FOR HIGH-DENSITY PROJECTILES

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OVERVIEW

- Introduction
- Experimental Methods
  - Selection of Materials
  - Injection Molding
  - Heat Treatment
  - Mechanical Tests
- Experimental Results
  - Tensile Test
  - Impact Test
- Conclusion
- Future Work
- Acknowledgements

INTRODUCTION

- Investigation of current and proposed sabot materials for launching high-density projectiles to examine the behavior of spacecraft materials under hypervelocity impact
- Sabot must:
  - Position and support the projectile during the launch
  - Seal the gases from the launch tube
  - Reduce movement of the projectile
  - Separate from the projectile without damaging the launcher

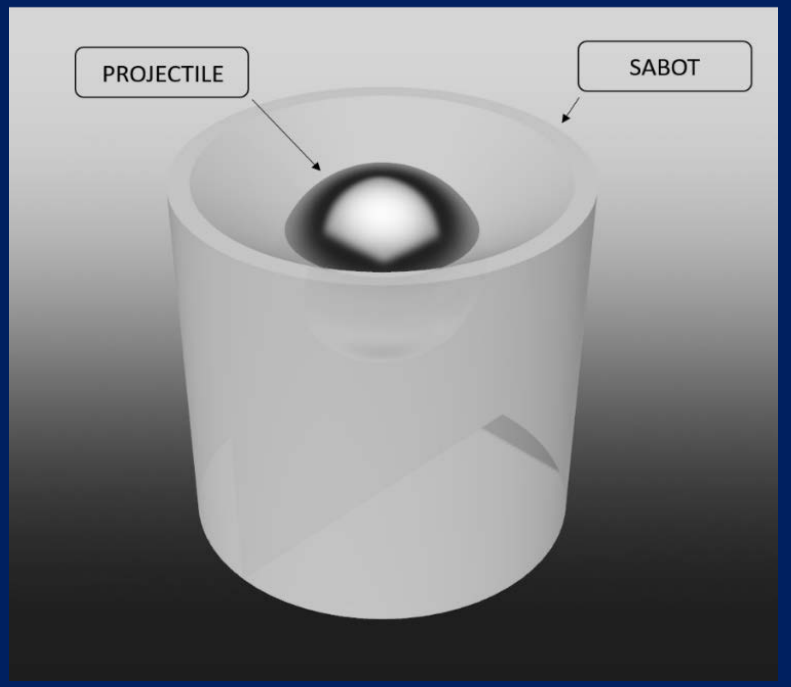

Fig 1. Sabot design carrying a stainless steel projectile.

INTRODUCTION

- Mechanical Tests
  - Tensile Test and Impact Test
- Monolithic Samples
  - Polycarbonate Optical Grade
  - Cyclo Olefin Polymer Grade 790R
- Compare materials by analyzing their respective mechanical properties

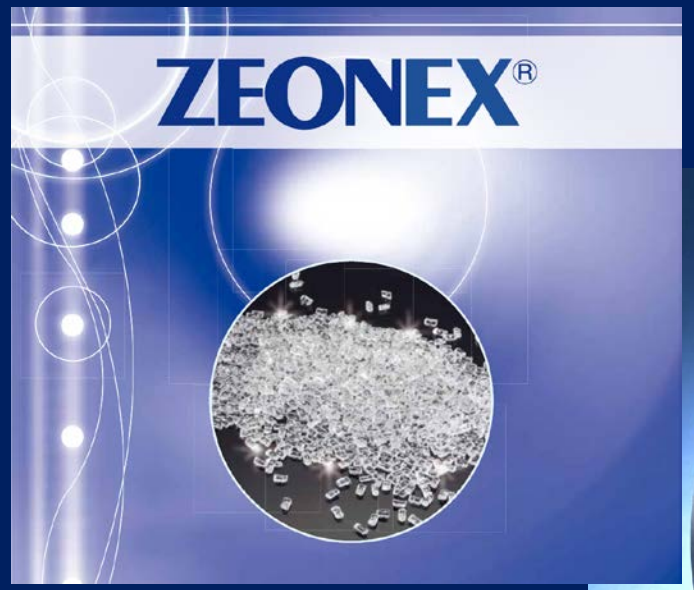

Fig 2. COP 790R. [15]

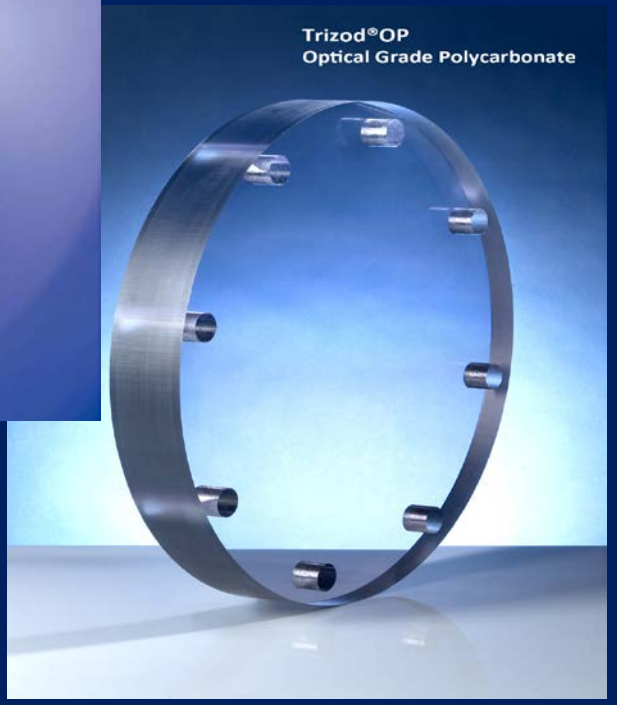

Fig 3. *Polycarbonate Optical Grade. [16]*

EXPERIMENTAL METHODS

SELECTION OF MATERIALS

- Low density-high strength → sustain higher velocities without risking material failure
- Low melting point → decreases barrel erosion

Table 1. Comparison of mechanical properties between polycarbonate and COP [8,9]

	POLYCARBONATE	CYCLO OLEFIN OLYMER
Density	1.20 g/cm^3	1.01 g/cm^3
Tensile Strength	62 MPa	71 MPa
Tensile Modulus	2,379 MPa	2,500 MPa
Flexural Strength	93 MPa	94 MPa
Melting Temperature	147 °C	138 °C

EXPERIMENTAL METHODS

INJECTION MOLDER

- LNS Technologies, Model 150A PIM-SHOOTER™
- Monolithic samples of COP
- Pellets were first pre-heated for 12 hours at 130 °C
- Barrel temperature: 276 °C
- Aluminum molds were pre-heated for 20 minutes at 150° C

Fig 4. Injection molding Model LNS 150A. [17]

EXPERIMENTAL METHODS

HEAT TREATMENT

- Annealing process forms additional crystals while cooling down to room temperature, which enhances mechanical properties
- Polycarbonate → 147 °C
- COP → 133 °C
- Decreases tensile and impact strengths

Fig 5. Polycarbonate two-piece 0.50 caliber sabot.

TENSILE TEST

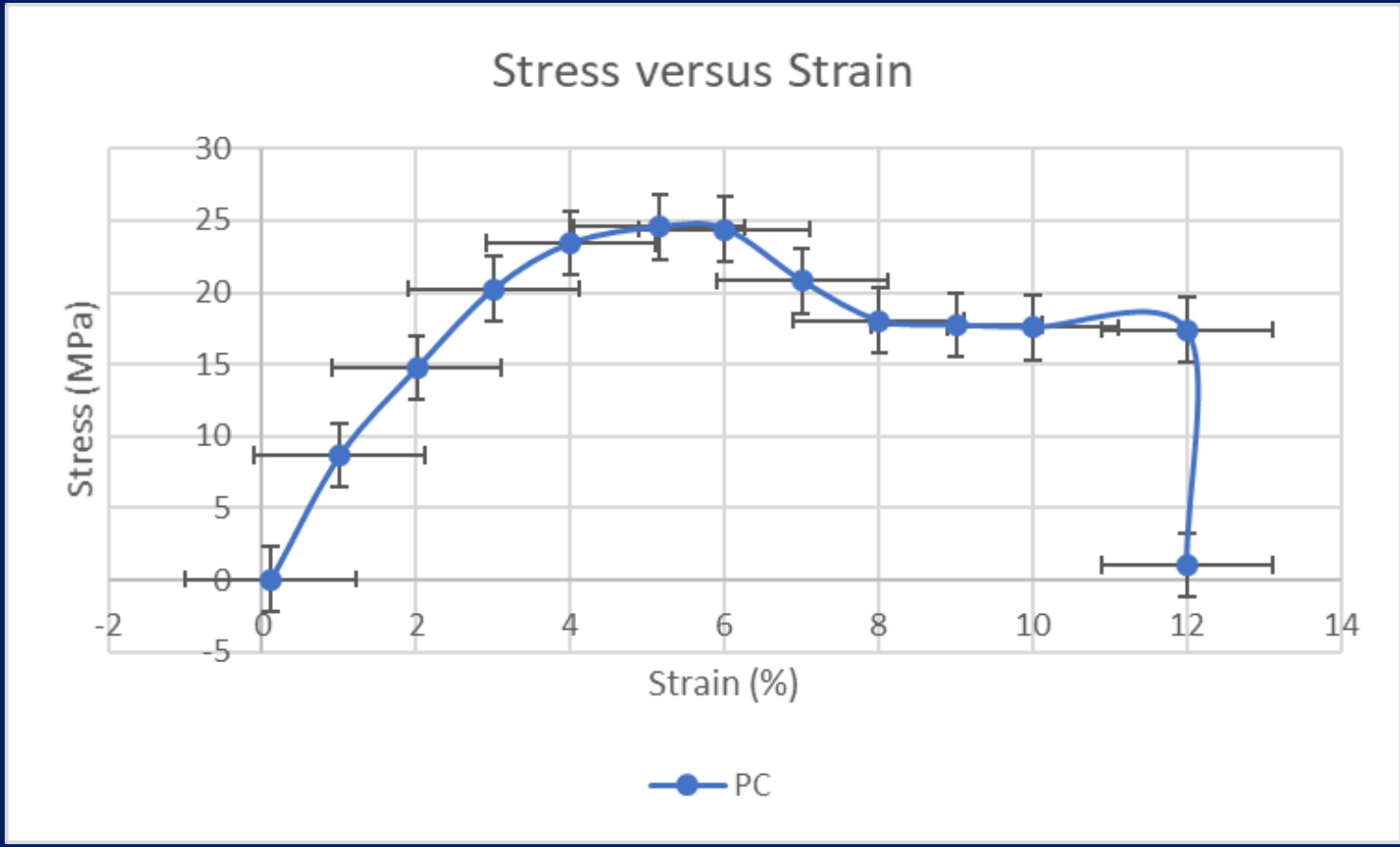

Fig. 6. Monolithic polycarbonate tensile test average results..

IMPACT TEST

Table 3. Comparison of Izod impact resistance results for monolithic samples of polycarbonate and COP

POLYCARBONATE OPTICAL GRADE		
Sample Number	**Impact Resistance (J/m)**	**Impact Strength (J/m^2)**
1	91.0	8860
2	91.6	8880
3	90.9	8860
4	88.4	8580
Average	90.5	8790

CYCLO OLEFIN POLYMER		
Sample Number	**Impact Resistance (J/m)**	**Impact Strength (J/m^2)**
1	69.9	6670
2	69.3	6670
3	70.1	6790
4	69.2	6650
Average	69.63	6695

CONCLUSION

- Based on the experimental data available, the mechanical properties of COP do not appear to exceed those of polycarbonate
- Completion of tensile testing is necessary to fully understand the mechanical properties of COP and to evaluate its viability as a sabot material

FUTURE WORK

- Completion of tensile testing
- Implementation of additive manufacturing for sabots will be another study
- Compare 3D printing samples of tensile and impact tests for both COP and polycarbonate to observe how properties vary from monolithic versus additive manufacturing samples
- Use dynamic mechanical analysis (DMA) to further evaluate COP properties as monolithic and as a filament
- Existing software such as CAD/Solidworks and finite element analysis (FEA) should be considered to calculate different internal stresses and to simulate the process of launching the sabot with a high-density projectile
- Produce a composite between COP and polymer to observe the reactions and their properties

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THANK YOU!
ANY QUESTIONS?