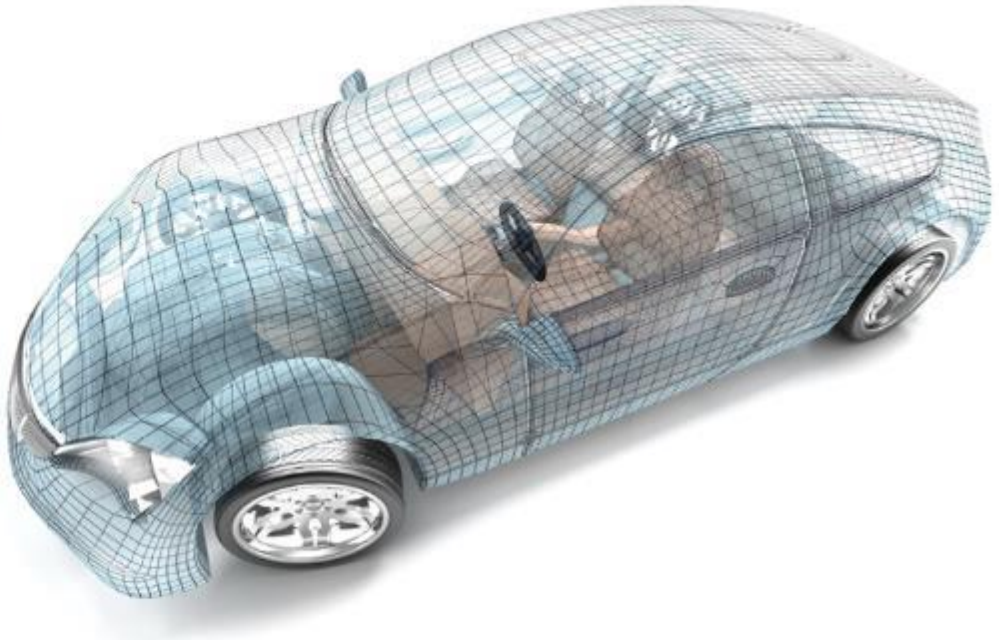
TCC 2020
THERMOPLASTIC COMPOSITES CONFERENCE

APRIL 29 – MAY 1, 2020 | SAN DIEGO, CA, USA
HYATT REGENCY LA JOLLA AT AVENTINE



Hybrid Overmolded Thermoplastic Composite Part Design

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Commercial Manager
TxV Aerospace Composites

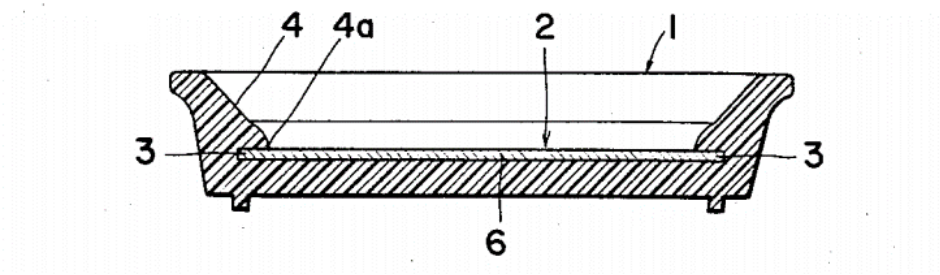
Overview:

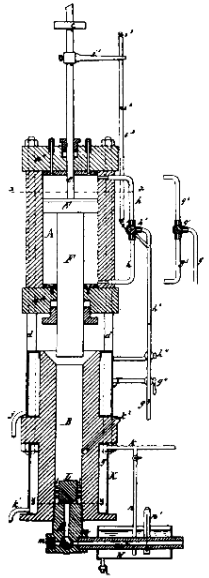
- History
- Overmolding materials & process
- SFS Case Study:
  - Part selection and problem identification
  - Design iterations
  - Process simulation
  - Validation
- Conclusions and areas for future study

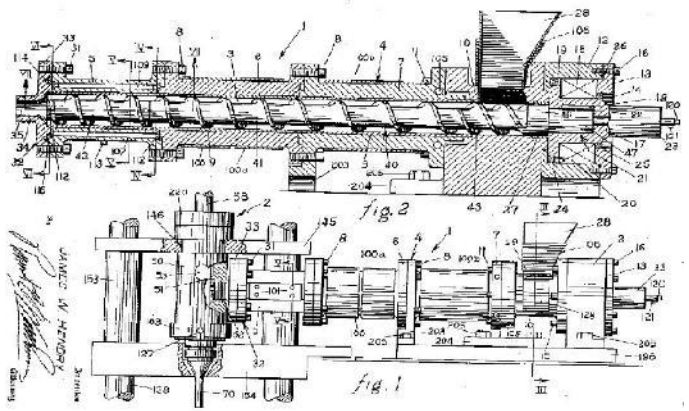
SFS in partnership with TxV AERO COMPOSITES

Brief History of Injection and Overmolding Technology:

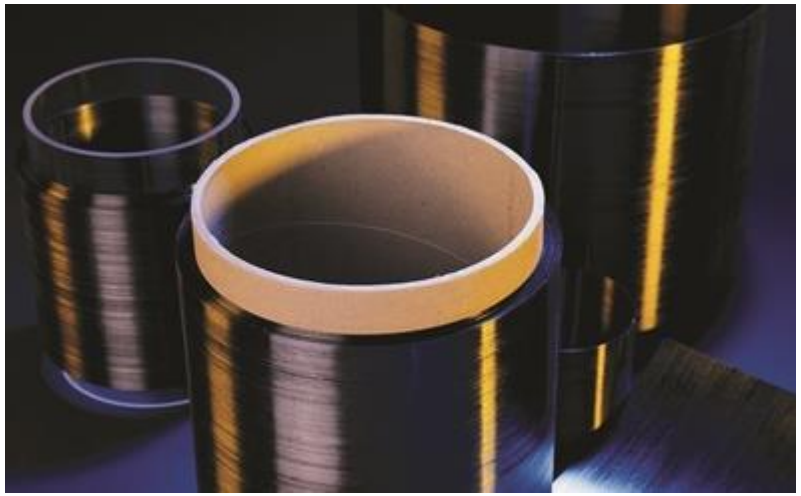
- 1872 – First U.S. patent for IM machine
- 1946 – First screw type IM machine built
- 1950 – 70's – Polymer boom
- 1968 – First U.S. patent filed for "over molding"
- 2015 – PEEK over PAEK (same polymer family)







- VICTREX AE™ 250 UD Tape
  - Low-melt PAEK continuous fiber reinforced materials are utilized to produce composite inserts (T_m 305 °C)
- VICTREX™ PEEK 150CA30
  - Higher melting short-fiber reinforced PEEK is melted and injection overmolded (T_m 343 °C)
- Temperature differential allows for a fusion bond to the lower melting continuous fiber reinforced PAEK



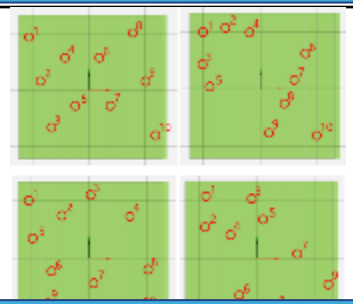
Property	Units	PEEK	VICTREX AE 250
T_g	°C	143	147
T_m	°C	343	305
Tensile Strength	MPa	100	90
Tensile Modulus	GPa	4.0	3.5
Elongation at Break	%	>60	>40
Fluid Resistance	-	Excellent	Excellent

HYBRID OVERMOLDING PROCESS

Automated Tape Laying

VICTREX AE™ 250 Tape Input

Tailored Layup Output

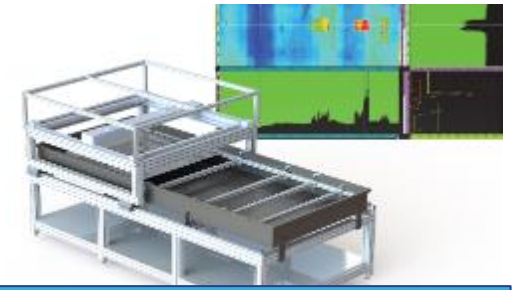


Inline Manual Ply Gap Inspection

Rapid Consolidation

Tailored Layup Input

Consolidated Laminate Output



Offline Automated Ultrasonic Inspection

Automated Forming

Consolidated Laminate Input
Forming Tooling

Formed Part Output

Offline Manual Ultrasonic Inspection

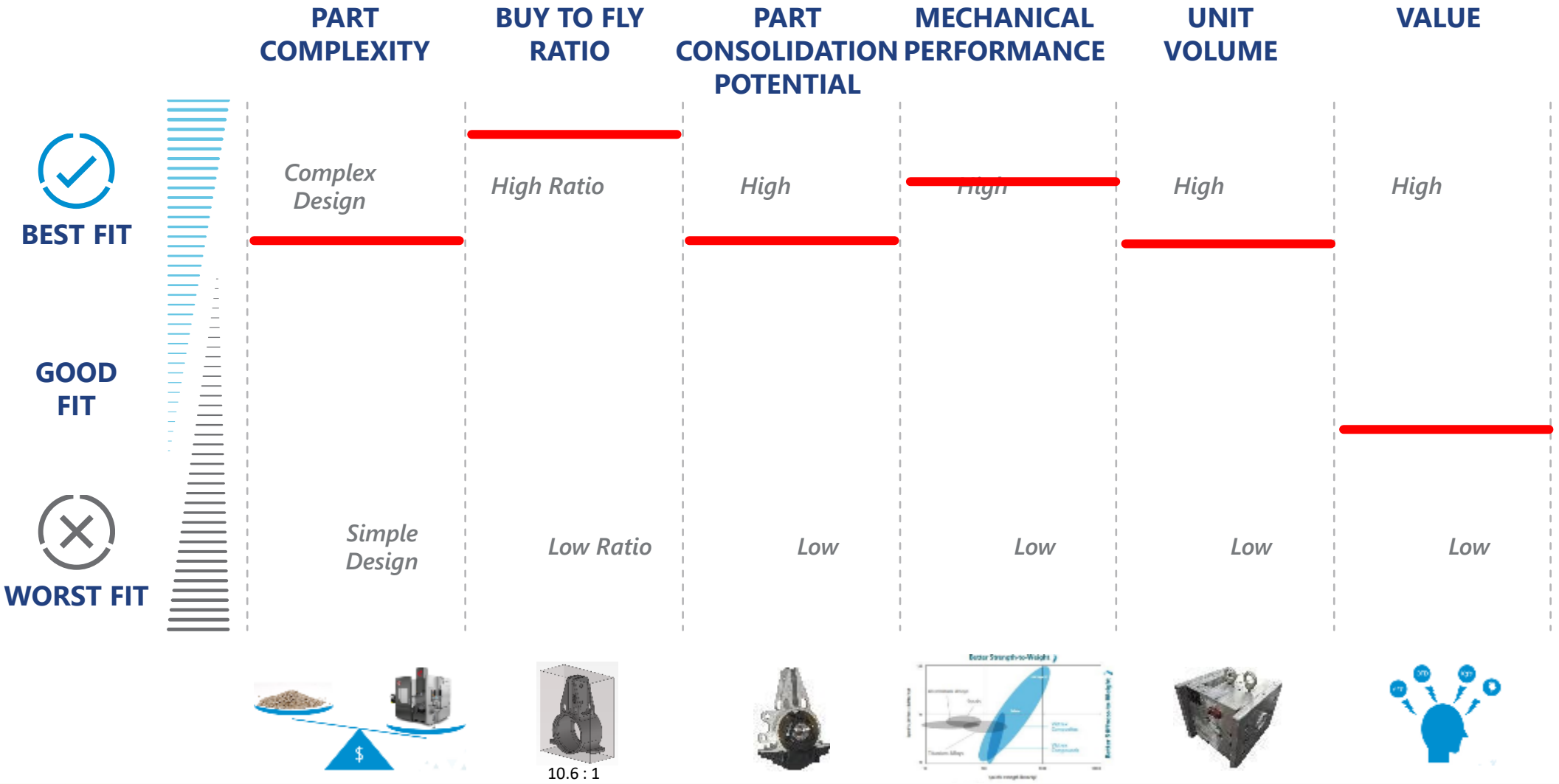
Injection Overmolding

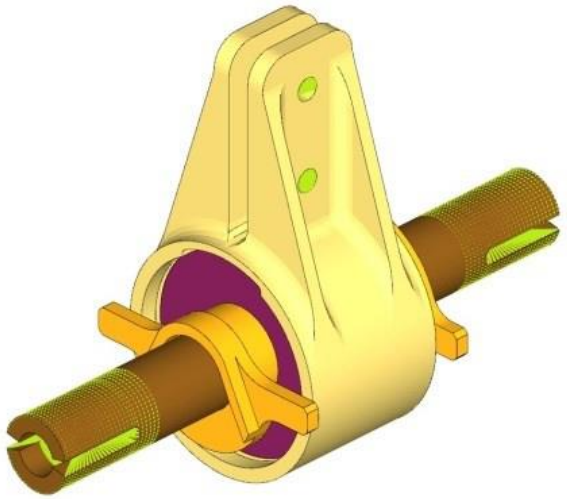
VICTEX PEEK™ 150CA30 & Formed Part Inputs
Injection Molding Tooling

Hybrid Part Output

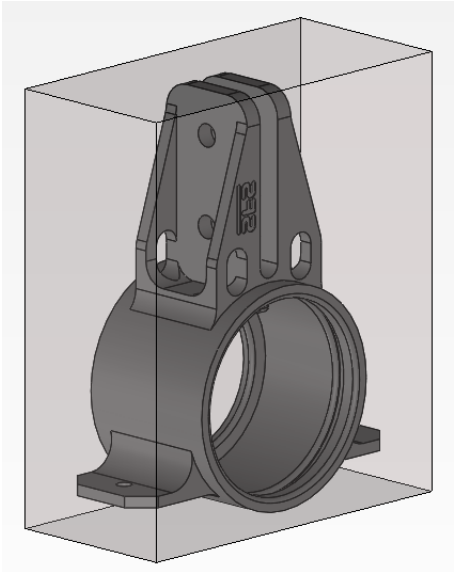
Offline CMM and Manual Ultrasonic Inspection

SFS A350 B-Bracket fit to the hybrid overmolding technology





Need for cost and weight reduction



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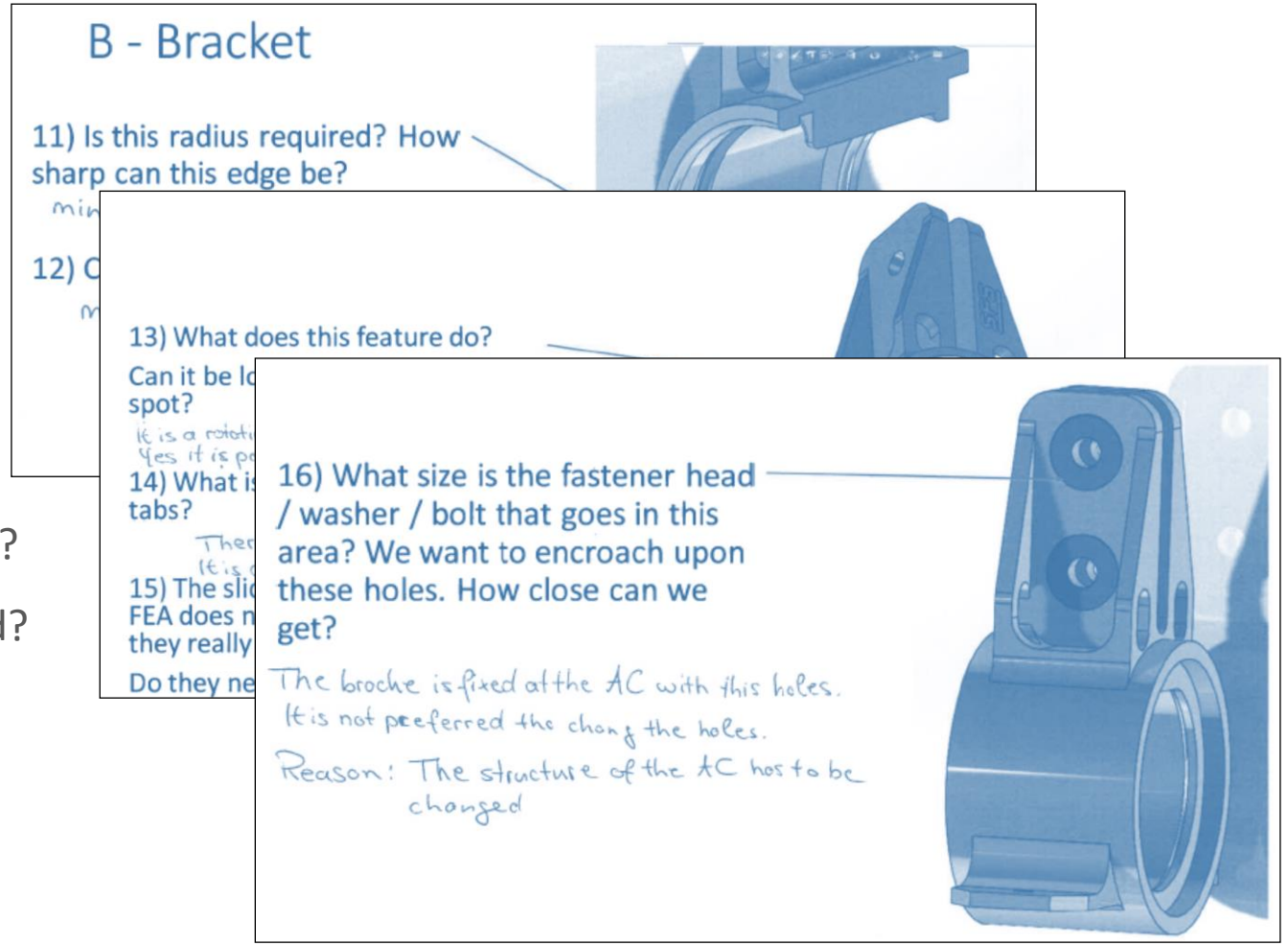
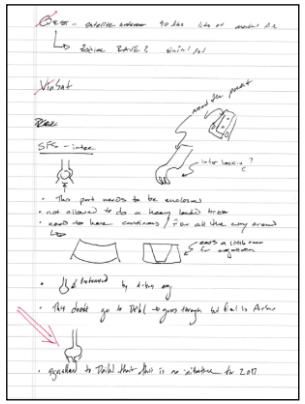
Customer Q&A

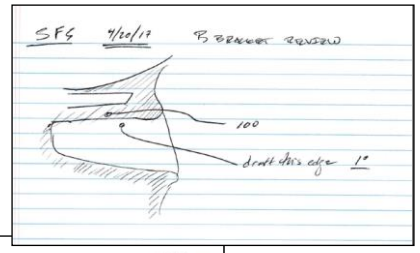
- What problem does it solve?
- Usage & intent?
- Loading in use, during testing?
- Design limitations / space envelope?
- Installation?
- Compromises were made for incumbent materials?
- Compromises made due to manufacturing method?

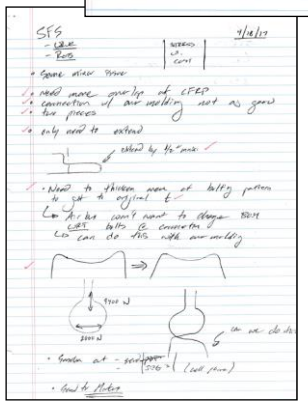


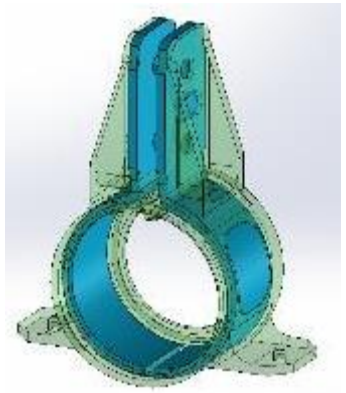
In-depth knowledge used to create a parallel solution

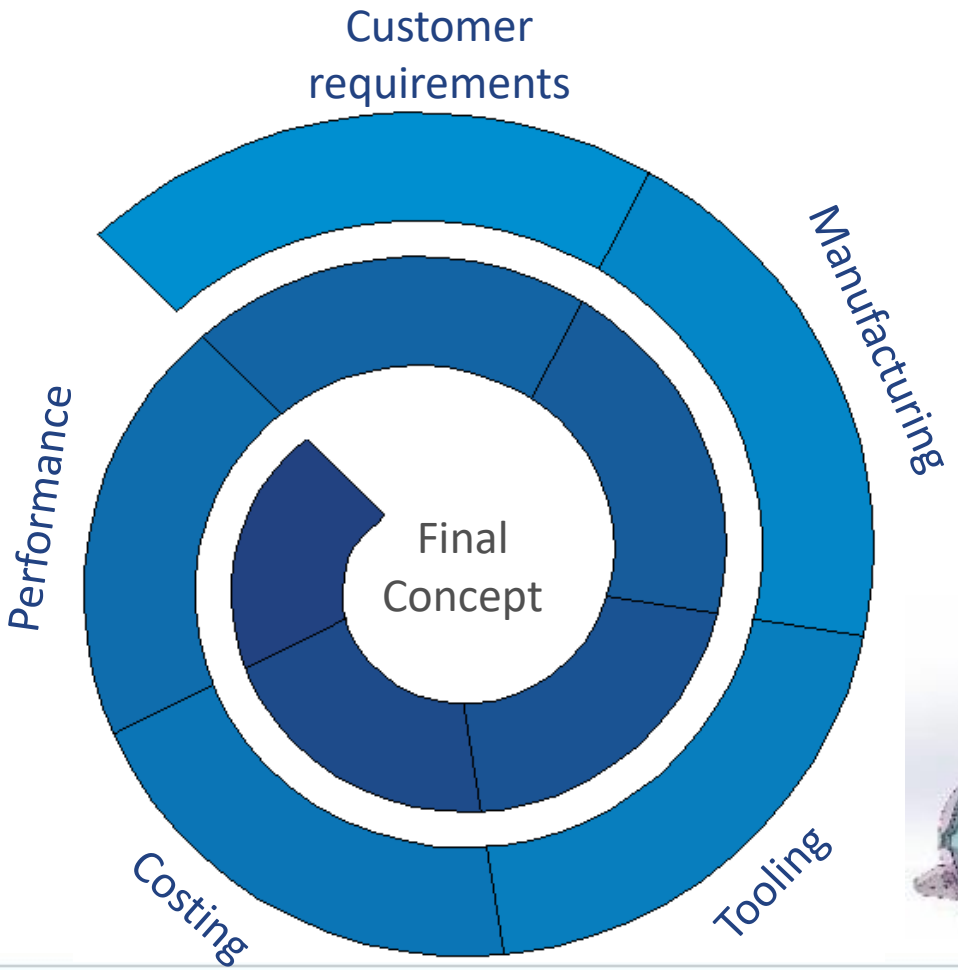
- Rapid iteration of design concepts
- Quick customer feedback
- Updated concepts based on better understanding of the problem at hand

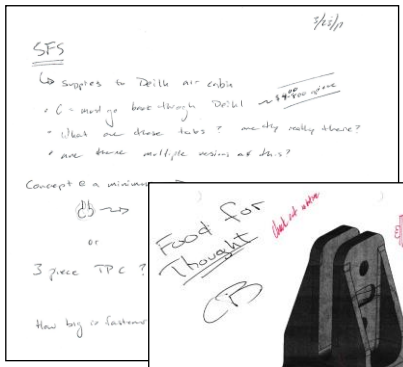


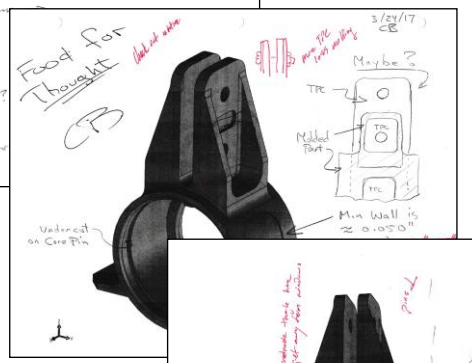


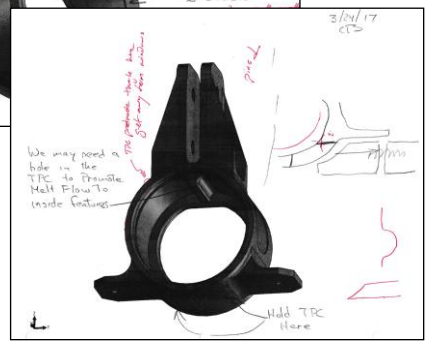


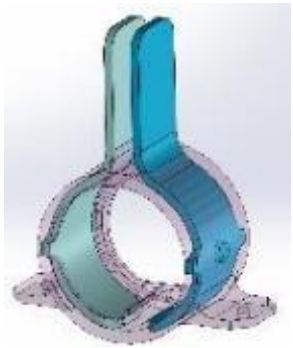




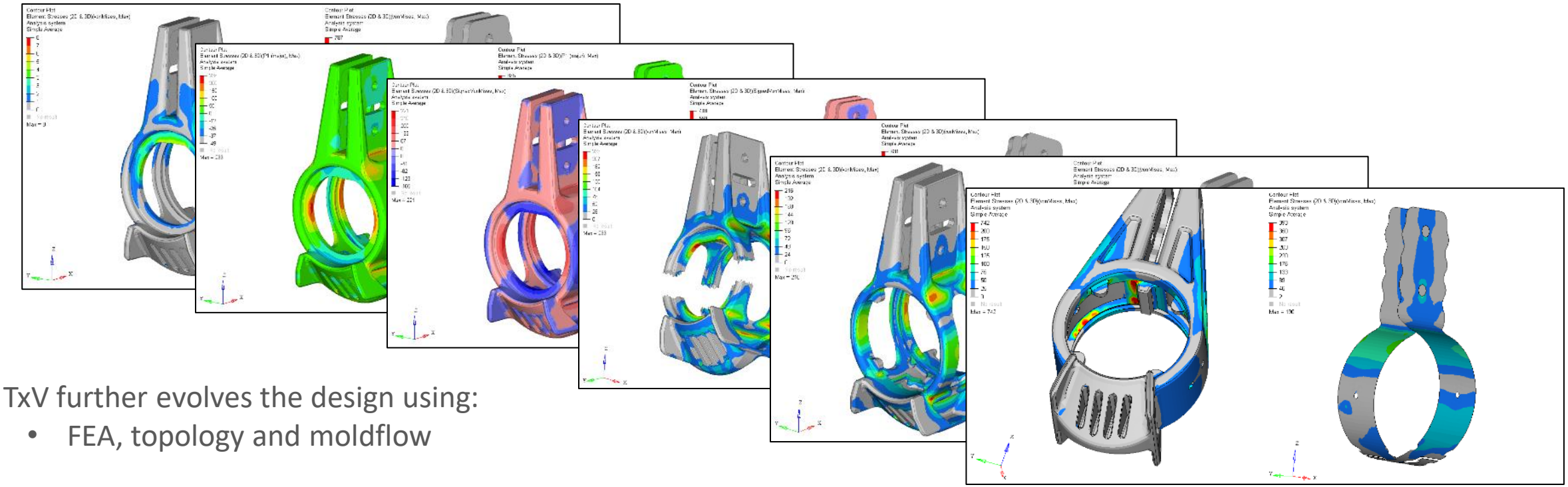




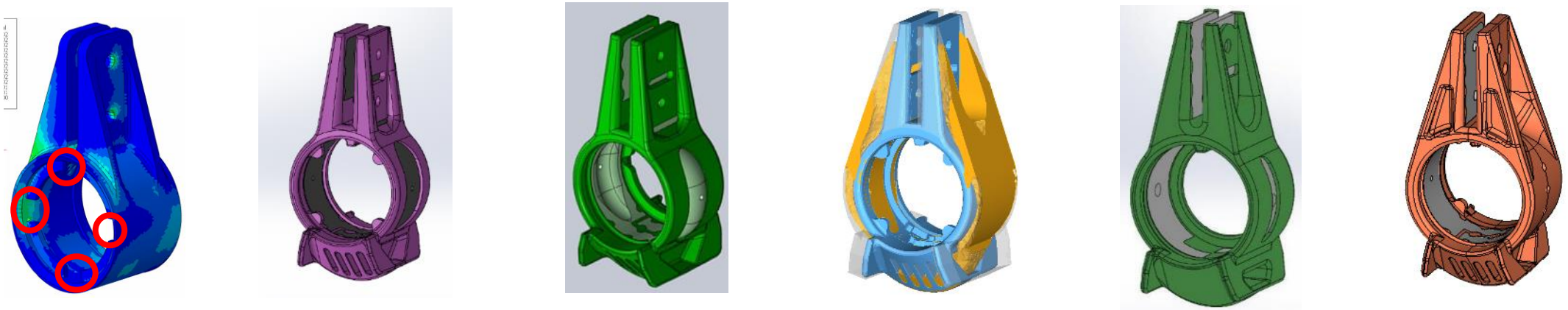




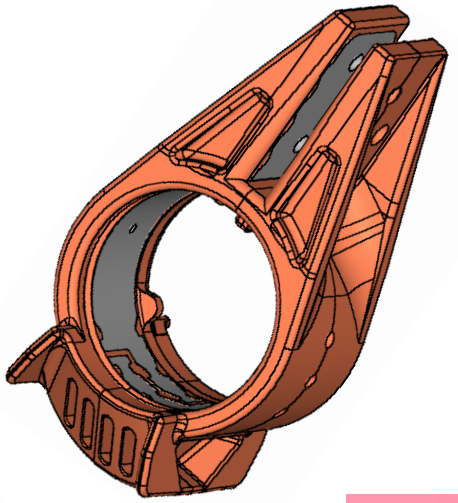
PERFORMANCE AND ANALYSIS BASED DESIGN ITERATIONS

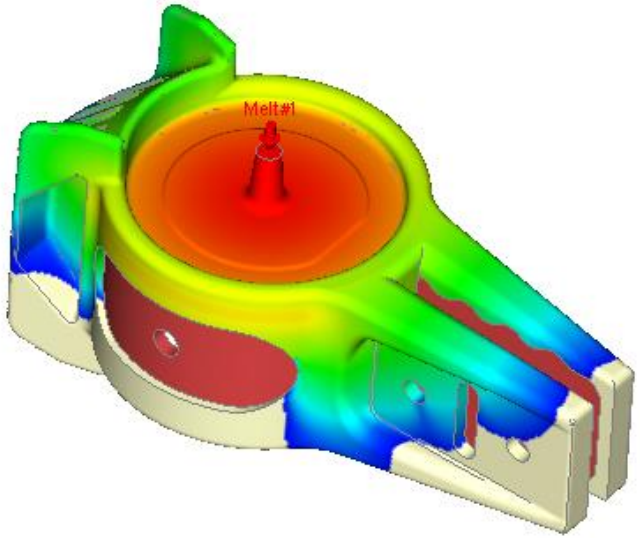


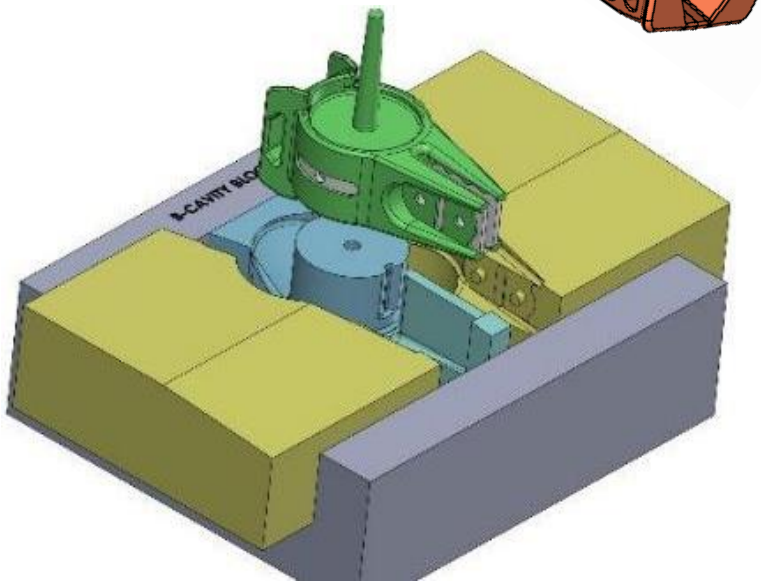
- TxV further evolves the design using:
  - FEA, topology and moldflow



- Agreement on final design
- Analysis tools predict successful performance
- TxV initiates a tooling design
- Moldfow and process simulations completed
- Part design modifications based on process and tooling constraints made as needed



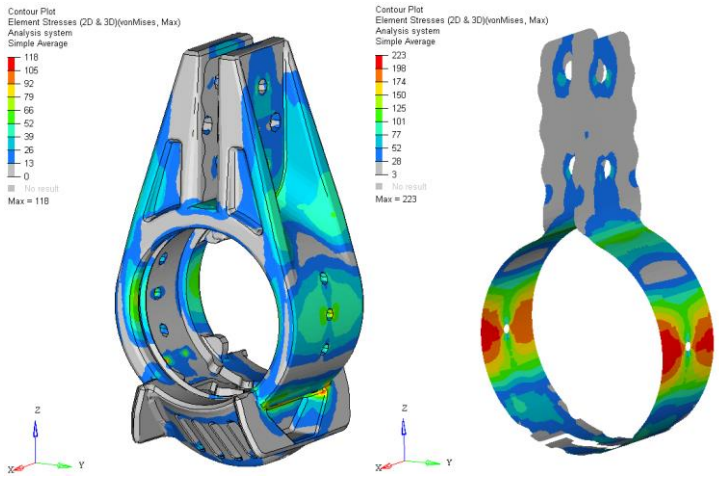




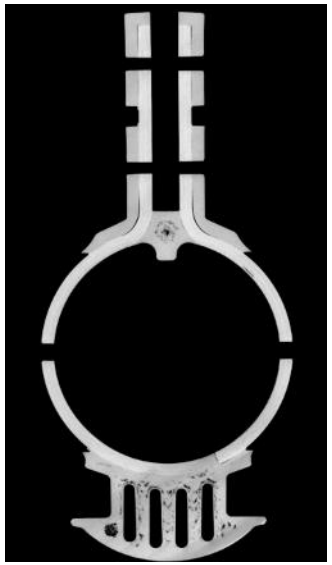
- TxV produced prototype parts
- Parts tested to validate design assumptions, analytical models and processing conditions
- Parts were submitted for qualification

Prototype parts

Preliminary testing

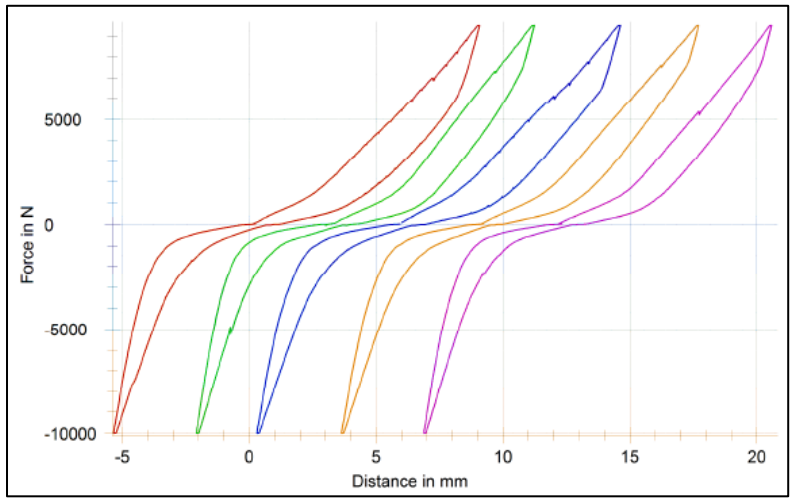


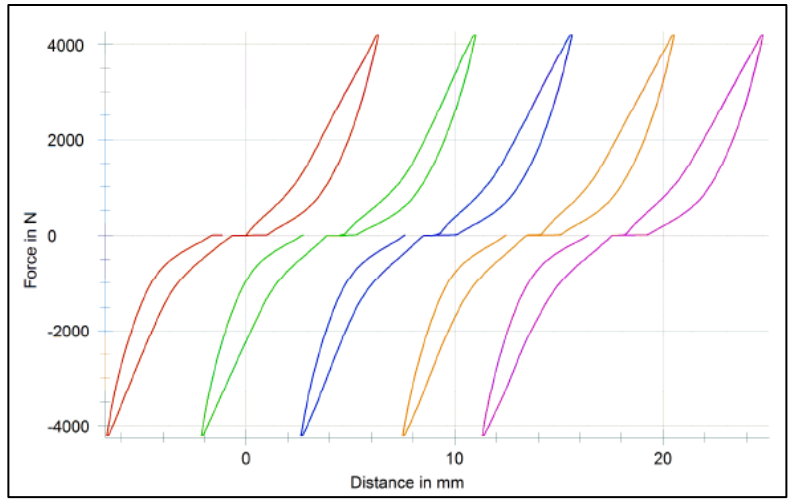
Validated models



CT scan

- Parts were submitted for qualification testing in two load directions (Z and Y)
- Ultimate loads 1.50 x operational
- Tested in +/- Z, cycle full reversal from +10000 N to -10000 N
- Tested in +/- Y, cycle full reversal from +4,200 N to -4,200 N
- Maximum loads at an additional safety factor of 6 – 10%
- No cracks or visible damage is permitted
- Subsequently pulled to failure





Y +/-4,200 N

Z +8,900 N
Z -9,400 N

- Hybrid PAEK composite injection overmolded PEEK bracket can replace machined from aluminum brackets
  - The hybrid bracket offers a ~30% mass reduction
    - As high as 60% possible
  - Part consolidation achieved reducing part count by 3
  - Part cost reduction of ~20%
- No surface preparation is required to achieve fusion bond
- Processing temperatures help until they don't
  - Higher melt seems to provide better interface bond
  - Insert deformation can be controlled with process optimization and tooling design
- Fundamental studies to optimize bond
  - Lap shear studies are underway
  - Processing guide to be made available

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Thank You

Questions?