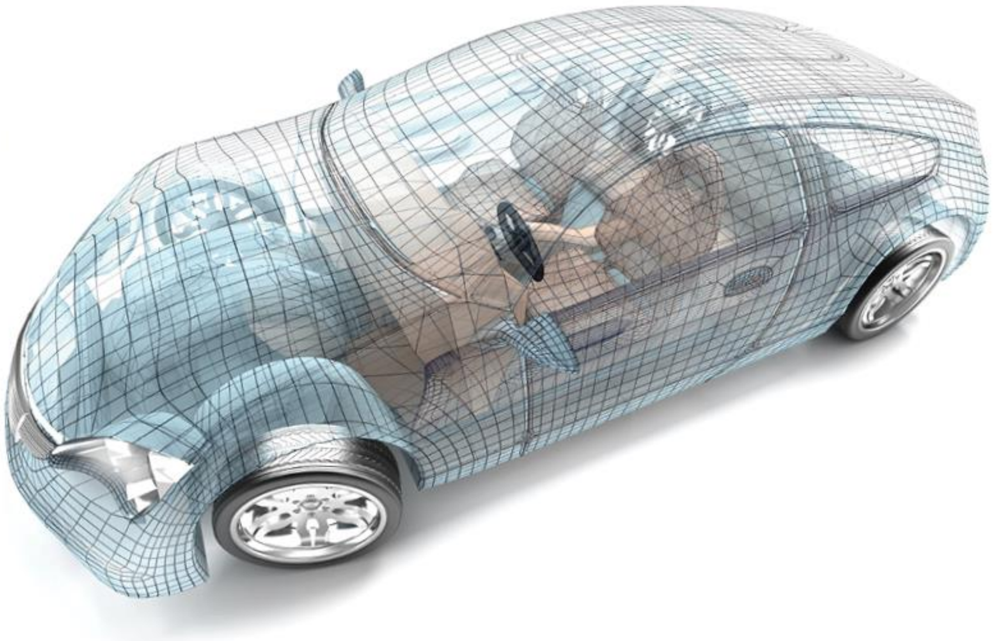
THERMOPLASTIC COMPOSITES CONFERENCE

TCC 2020

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



Fiber Reinforced Thermoplastic Implementation Challenges and Opportunities In Aerospace.

Presented By: Trevor McCrea
Director – R&D and Engineering
ATC Manufacturing

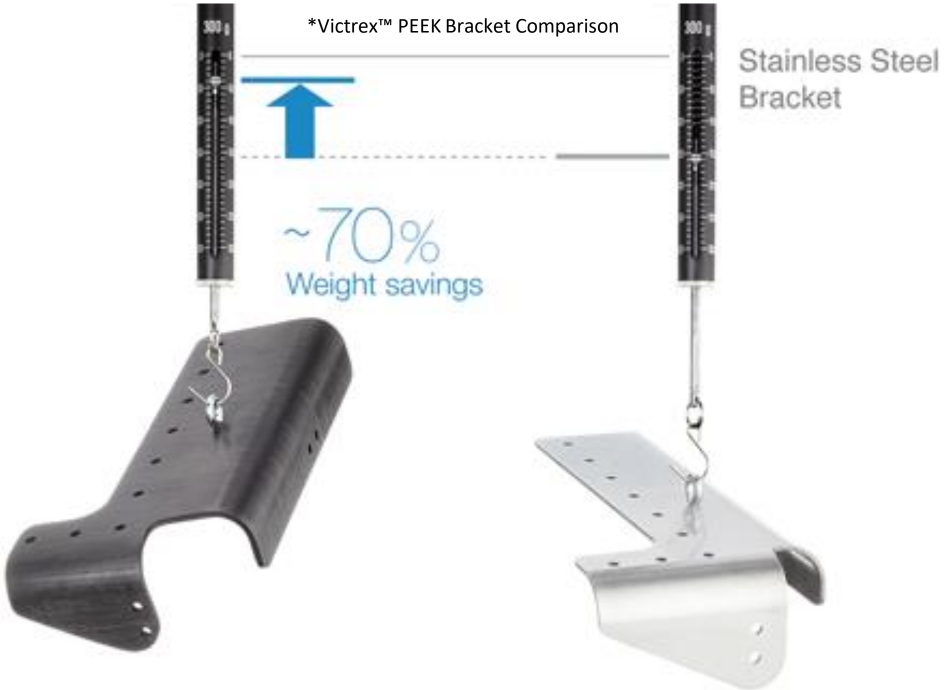
Topics covered:

- » Introduction to “Why Thermoplastics?”
- » Forming processes and challenges
- » Practical considerations
- » Thermal management
- » Raw material effects
- » Simulation methods
- » Stamp form processing experience
- » What “the future” is asking for?
- » Questions

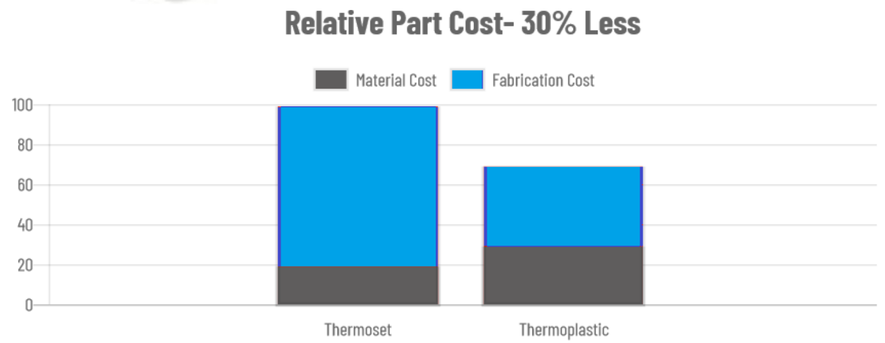
Introduction to Continuous Fiber Reinforced Thermoplastic Structures for Aerospace Applications

>> **Thermoplastic Composites Benefits**

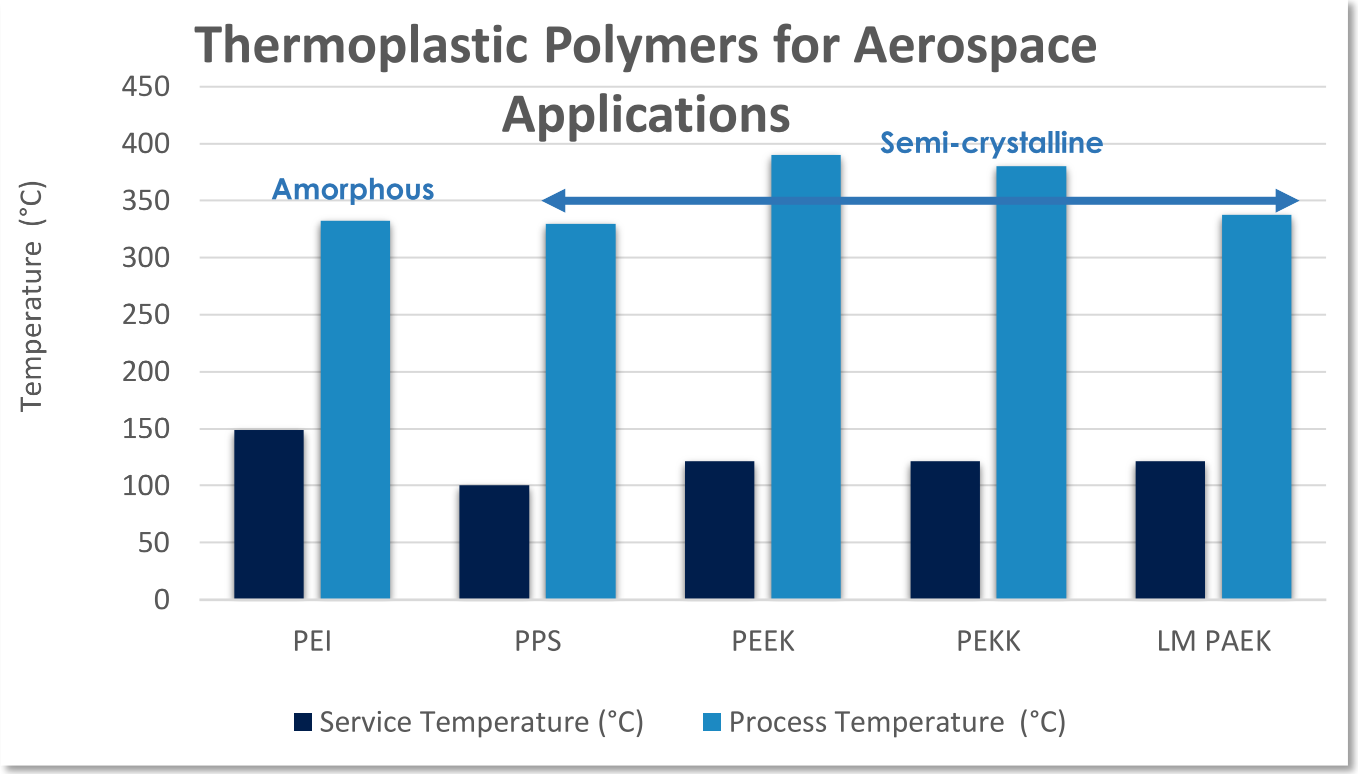
- are **light weight** and **low cost** for **high volumes**
- processed in **rapid cycle times**
- production is **readily scalable**
- High **performance**
- can be **stored indefinitely**



>> Used in many commercial aircraft applications – more so in Europe than USA



Introduction to Continuous Fiber Reinforced Thermoplastic Structures for Aerospace Applications



Maximum Service Temperature recommended for aircraft structural use based on the CMH-17 guideline of Tg – 50F (28C)

Service temperature must be determined by designer based on service requirements

>> Reinforcements

- Glass Fabric
- Carbon Fabric
- Carbon UD Tape

>> Product Forms

- Prepregs – Fully or Partially impregnated
- Laminates

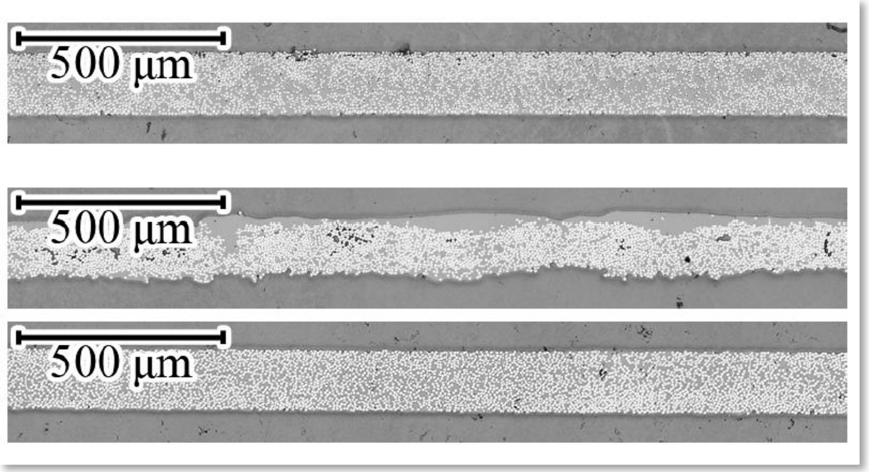
>> Fiber Volume

- 55-60%

Introduction to Continuous Fiber Reinforced Thermoplastic Structures for Aerospace Applications

>> Previous **Thermoplastic Composites** Adoption limiters

- Maturity of **materials** and **processes**
- Lack of Supply Chain **capacity** and **capability**
- **Design allowables** for use in industry
- **Design tools** for process and fabrication methods
- Insertion Opportunities



Slange et al, 20th ESAFORM Conference 2017

>> **Prepreg** Characteristics

- Limitations of **product forms** available
- Polymer content and fiber areal weight **consistency** > ply thickness
- Fiber-polymer distribution
- Degree of **impregnation**

Now these previous Adoption limiters are removed and the timing for growth is now!

Continuous Fiber Reinforced Thermoplastic Structures for Aerospace Applications

Primary Processes at ATC Manufacturing

Continuous Compression Molded Laminates for Blanks

- Laminate thickness 1 – 12 mm
- UD tape & fabric. PPS, PEEK, PEKK and other polymers
- Two flat CCM Lines up to 660 mm width
- Economical and consistent laminate manufacture

Stamp Formed Parts

- Transfer heated blank to stamping press – constant temperature
- Ten custom designed presses – range of sizes
- Automated for economic fabrication

Continuous Compression Molded Profiles

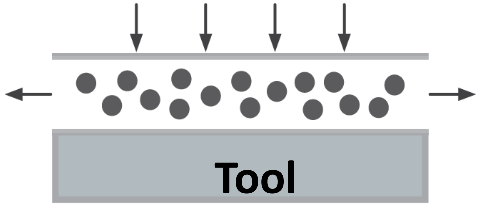
- Manufacture continuous profiles eg ‘C’, ‘T’, ‘H’, ‘J’ etc.
- Cross-section up to 300 x 200 mm
- Enables long profiles and economies for other parts
- Profiles >25 m long

ATC ADVANCED THERMOPLASTIC COMPOSITES

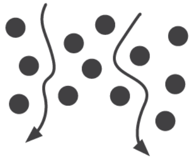
Supply > 100,000 Primary and Secondary Parts per month

Challenges & opportunities presented as the TPC market grows in rate, complexity, and physical size

1 **Transverse Ply Flow**



2 **Resin Percolation**

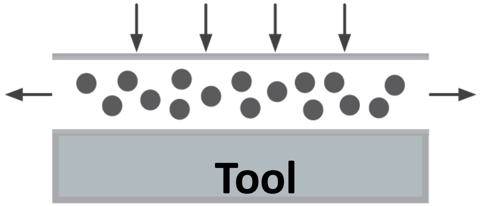


3 **Interlaminar Shear between**

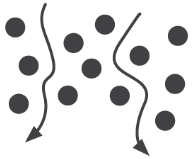
4 **Intralaminar Shear within**

Challenges & opportunities presented as the TPC market grows in rate, complexity, and physical size

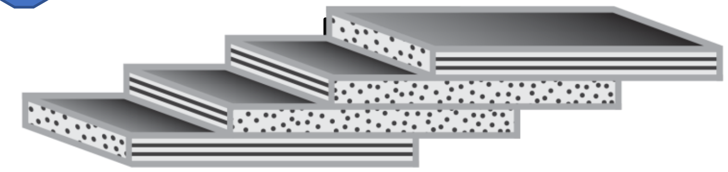
1 Transverse Ply Flow



2 Resin Percolation

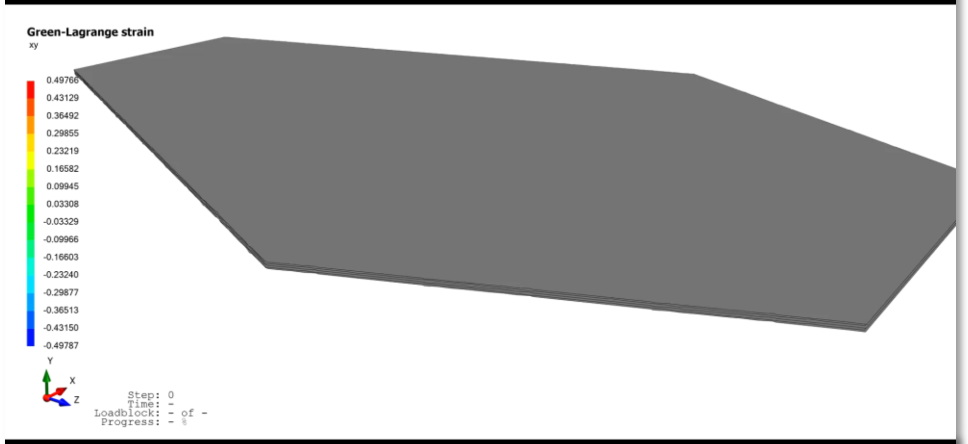


3 Interlaminar Shear between

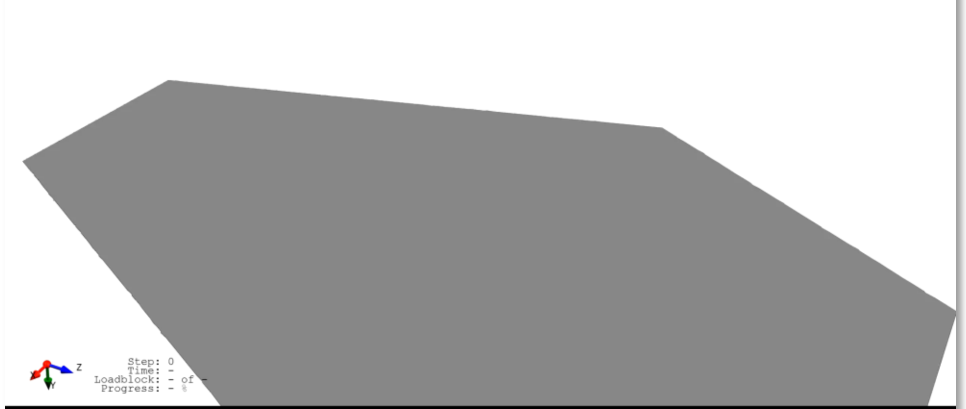


“Bathtub” Fitting Example

4 Intralaminar Shear within



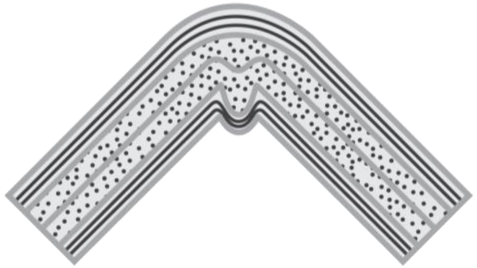
Green - Lagrange Strain

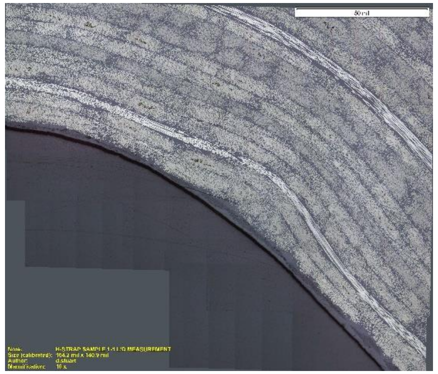


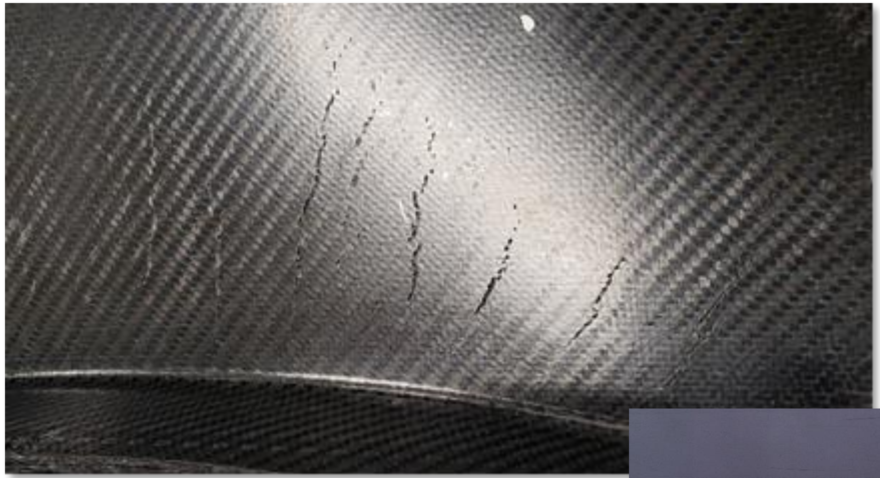
Ply Direction Influence

Challenges & opportunities presented as the TPC market grows in rate, complexity, and physical size

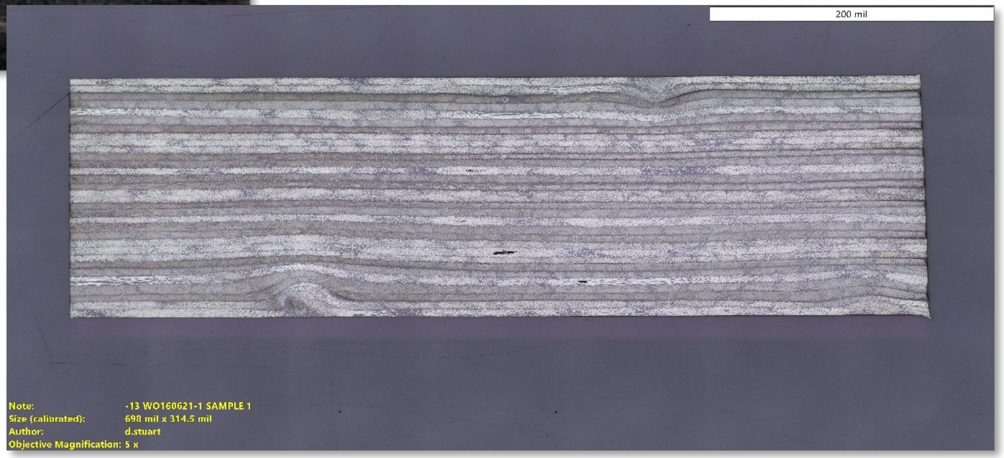
5 Ply Wrinkling







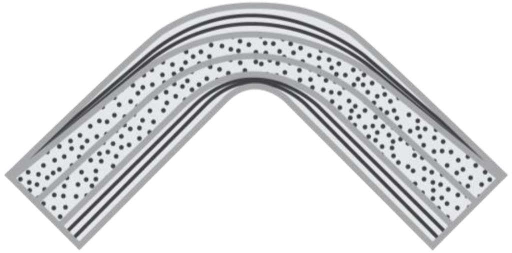
Fabric wrinkling due to inner flange compression - Credit - DARPA 2017



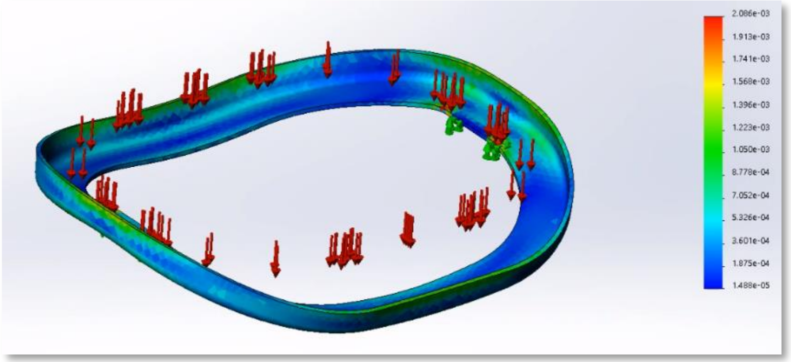
Uni-directional Tape wrinkling

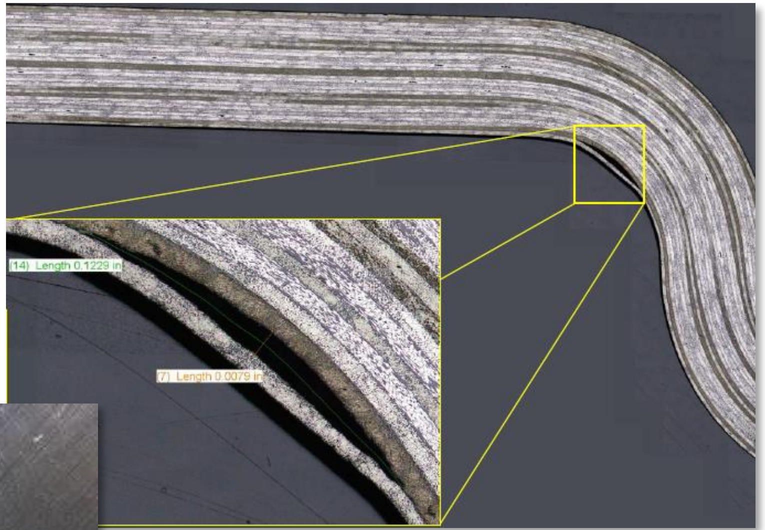
Challenges & opportunities presented as the TPC market grows in rate, complexity, and physical size

6 Ply Thinning & Bridging



Thinning due to radii tighter than material thickness





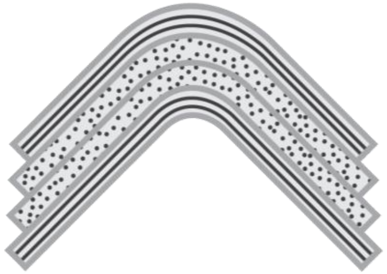
Geometry Effects

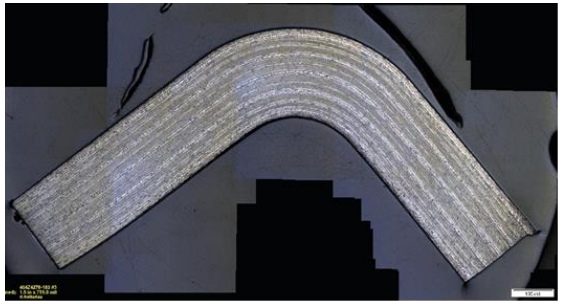
- Extreme Geometries
- Compound Contours
- R/T < 1

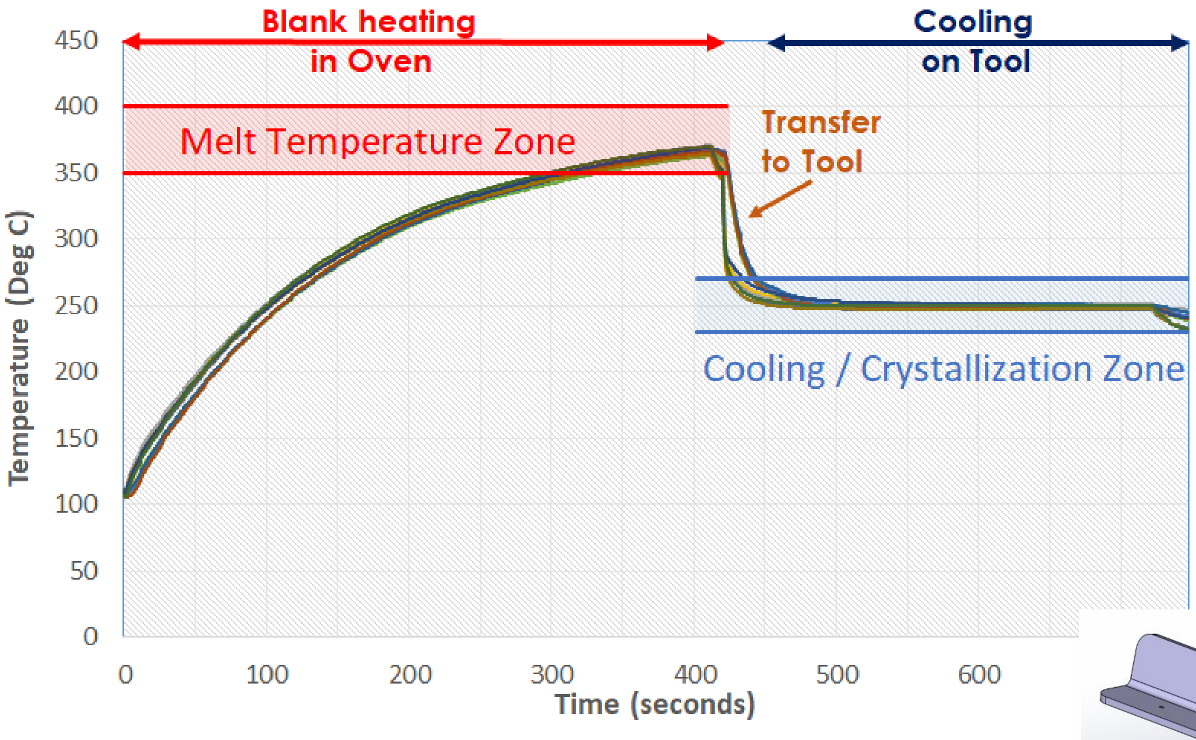
Outer Radii Fiber Bridging w/ UD Tape

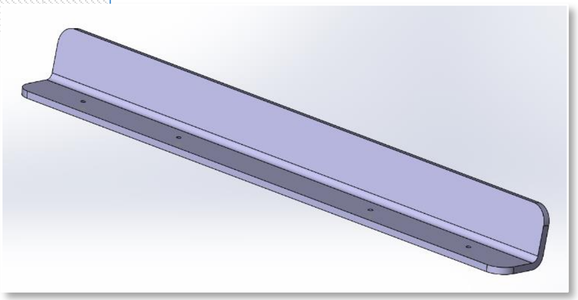
Challenges & opportunities presented as the TPC market grows in rate, complexity, and physical size

7 Ideal Case - Inter-ply Slip





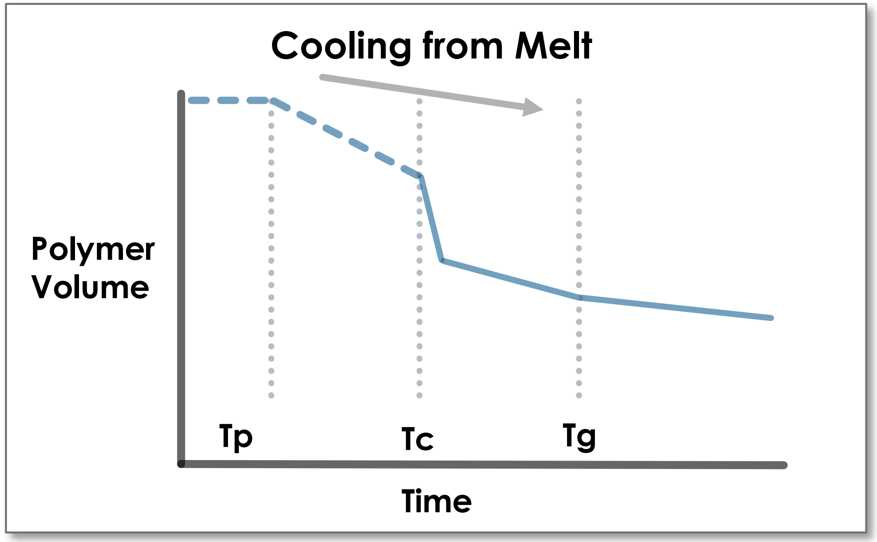




PEKK/CF UD Tape
36-ply
Thickness 5.0 mm

Challenges & opportunities presented as the TPC market grows in rate, complexity, and physical size

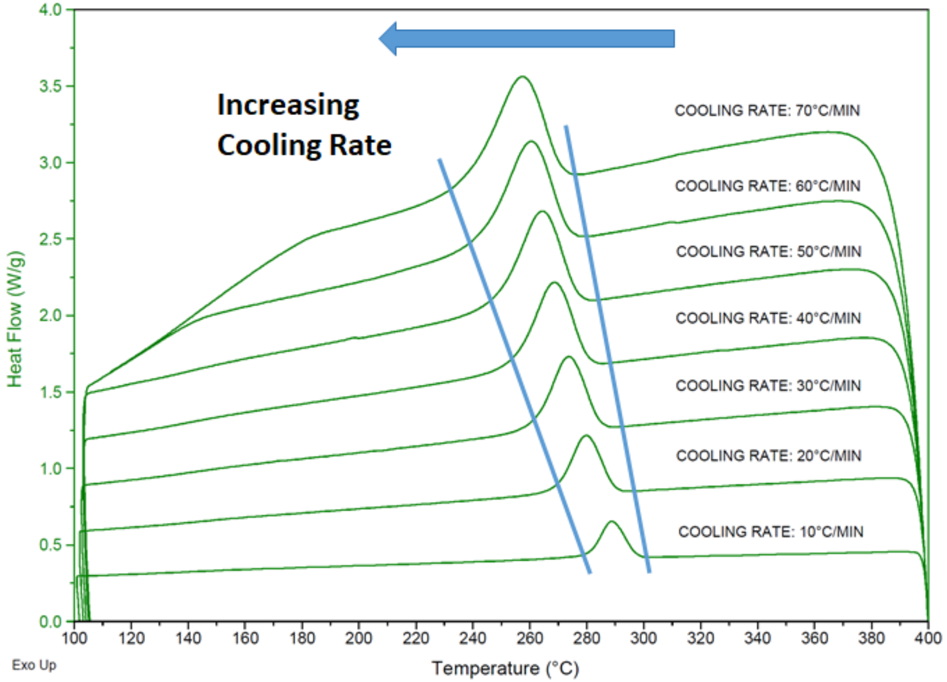
8 Thermal Effects vs Time



Polymer volume change on cooling for a semi-crystalline polymer

Time-Temperature Parameters

- Pre-heat temperature
- Blank temperature
- Transfer time
- Tool temperature
- Time on the tool

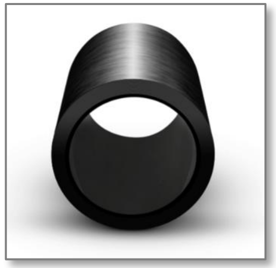


DSC at Various Cooling Rates PEEK/CF

Future Needs Where Fiber Reinforced Thermoplastics can excel


Aircraft Engines (*Collins*)

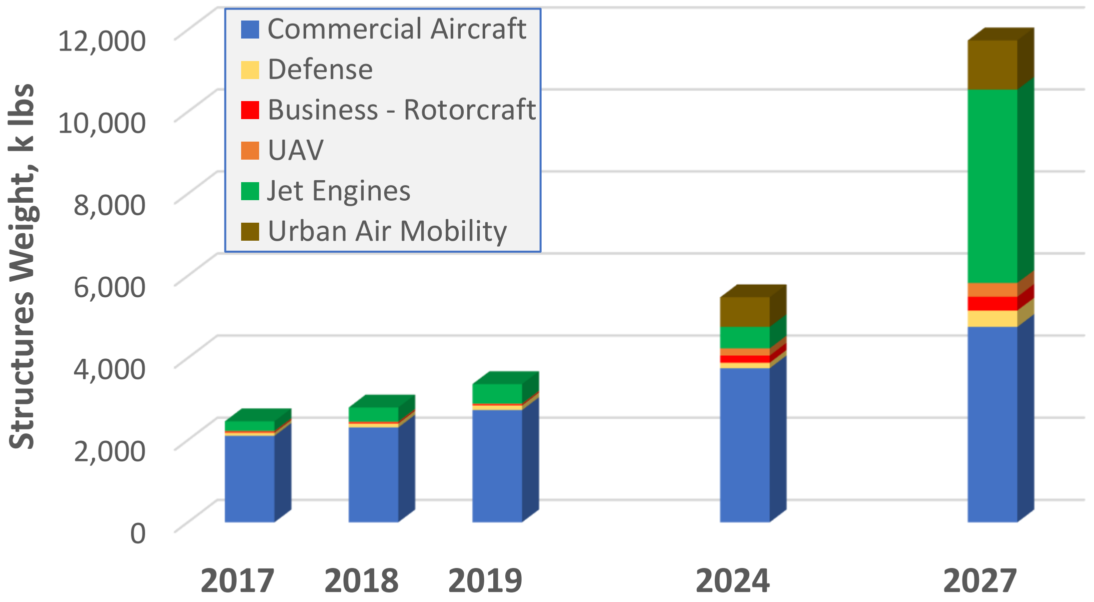

Urban Air Mobility (*Bell Nexus*)


Energy


Health Care

- >> **Commercial aircraft** applications established
- >> Expansion in **new aircraft** programs
- >> Growing market for **DoD applications**
  - » Rotorcraft
- >> Large potential in **Urban Air Mobility**
- >> **Other markets**:
  - » UAVs, UAMs,
  - » Next generation of commercial aircraft
  - » Other markets eg engines, energy, medical

Thermoplastic Composites in Aerospace Applications



CompositeTechs and ATC Market Analysis

Opportunities for Aerospace Applications

ADVANCED THERMOPLASTIC COMPOSITES

Aerospace Requirements at Automotive Rates

Thermoplastic Composites – Sustainable and Recyclable

Future Needs Where Fiber Reinforced Thermoplastics can excel

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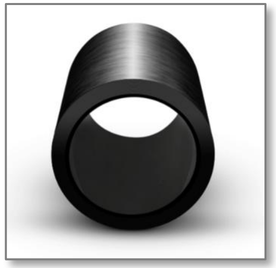
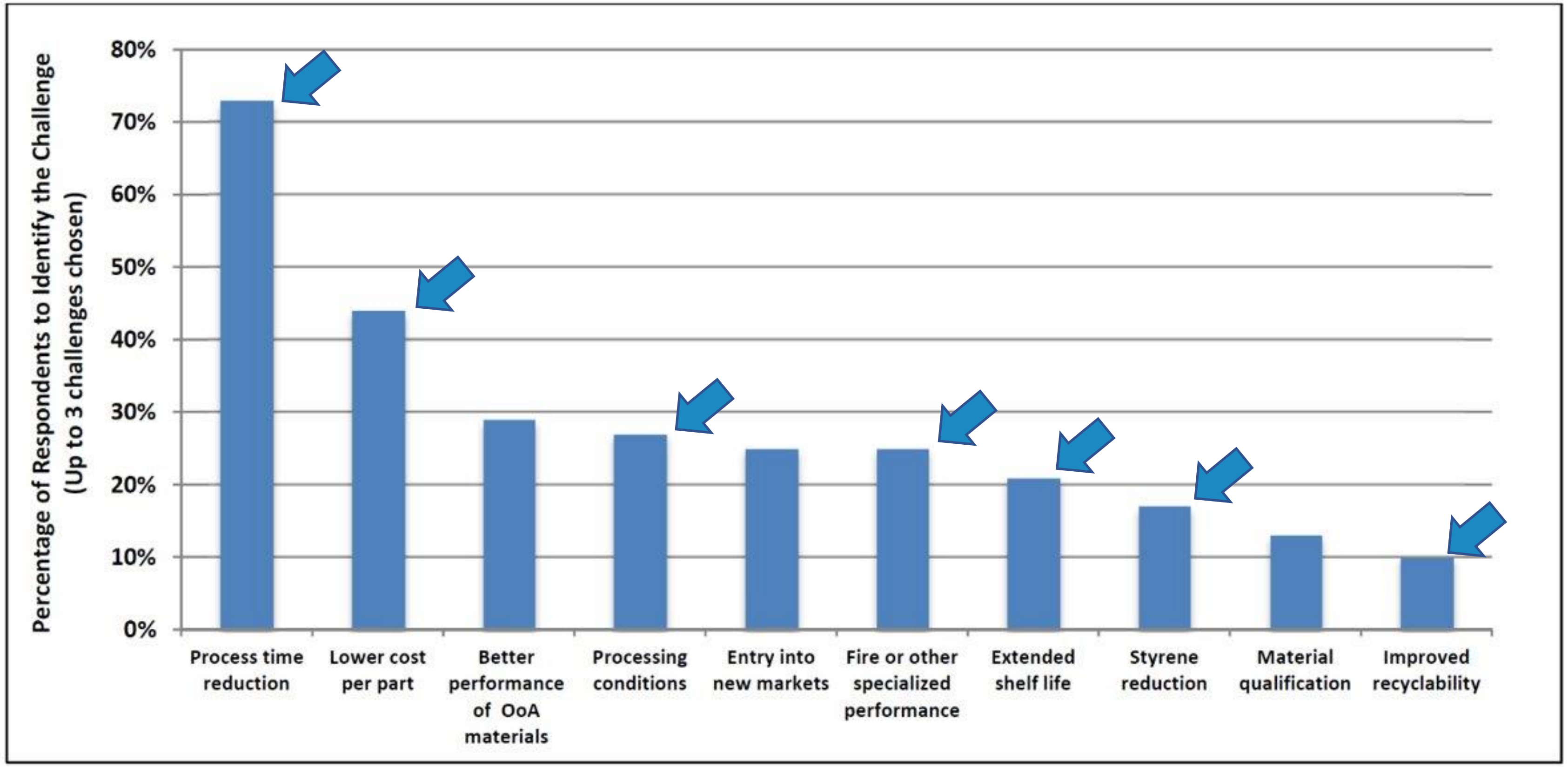


Energy

Health Care



U.S. Composites Manufacturing Industry Technical Roadmap

NIST Report, Award 70NANB14H057, August 2017

ATC ADVANCED THERMOPLASTIC COMPOSITES

www.atcmanufacturing.com

Questions?