SMART Wind Consortium Subgroup Virtual Meeting:

Composite Materials and Process Opportunities

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Opportunities to Improve Manufacturing

Metal to Plastic Conversion…
Injection Molding of Component Parts

- One method for evaluating the pros and cons of conversion is to assess the primary performance demands like:
  - System operating temperature range
  - Maximum load, stress and deflection conditions
  - Creep and fatigue constraints
  - Wear limitations (tribology) and the types of materials to which the parts will mate
  - Impact or shock-load requirements
  - Chemical contact or use inside the system
  - UV or other weatherability requirements
  - Part consolidation potential

Material Pros and Cons

- **Material choice will impact manufacturing and assembly costs**
  - Molded or machined cost per unit
  - Lighter weight plastics, offer more advantages when manufacturing and assemblies are considered
  - Mold life for plastic parts is typically ten times that expected from a die cast mold for aluminum
  - Usually metal castings are near-net shape and require numerous additional steps for final precision. Plastic components are usually molded to final dimensional and finish requirements
  - Many metal parts also need either a coating (paint, oil, etc.) or anodizing for corrosion protection. Plastic materials are often inherently corrosion resistant
  - Metal parts generally can't be switched to a less-expensive metal without going through a redesign. In contrast, less-costly plastics can often use the same molds as their more-expensive predecessors

Metal to Plastic Conversion is used to *Improve Products*, *Reduce Costs* and *Streamline Manufacturing*

- **Improve Products**
  - •Designs consolidate parts and create additional performance features
  - •Ability for more complex shapes and geometries
  - •Opportunity to combine materials for enhanced features using multi-shot molding, over-molding or insert molding
  - •Increased strength and durability
  - •Enhanced decoration or labeling with in-mold decorating and labeling
  - •Improved aesthetics
  - •Ability to maintain close tolerances
  - •Plastic materials and construction absorb impact and reduce noise
  - •Lighter weight components for improved product performance

Metal to Plastic Conversion is used to *Improve Products*, *Reduce Costs* and *Streamline Manufacturing*

- **Reduce Costs**
  - •Reduced secondary operations, such as painting, machining or assembly
  - •Improved production consistency
  - •Reduced part / product weight – reduced shipping and operating costs
  - •Product improvements resulting in increased customer satisfaction and decreased warranty issues
  - •Streamlined manufacturing cost savings
  - •Reduced scrap and waste
  - •Part consolidation

Metal to Plastic Conversion is used to *Improve Products*, *Reduce Costs* and *Streamline Manufacturing*

- **Streamline Manufacturing**
  - •Reduced labor and time, eliminating secondary operations and assembly
  - •Plastic injection molding is a faster and more consistent manufacturing process than metal fabrication
  - •Tools for testing materials and performance in the design phase predict performance

HARBEC™ INC

TECHNICAL INNOVATION WITH ENVIRONMENTAL RESPONSIBILITY

CNC MACHINING

INJECTION MOLDING

SUSTAINABILITY

MOLD MANUFACTURING

RAPID PROTOTYPING

2015 Capabilities Overview

HARBEC INC
TECHNICAL INNOVATION WITH ENVIRONMENTAL RESPONSIBILITY

INJECTION MOLDING

- Injection Molding
  - >30 electric presses; 55 – 400 tons
  - All production volumes
  - Clean room molding

- Value-added Operations
  - Assembly
  - Decorating
  - Kitting & Logistics
- 5-days/3-shifts per week

HARBEC Injection Molding Production

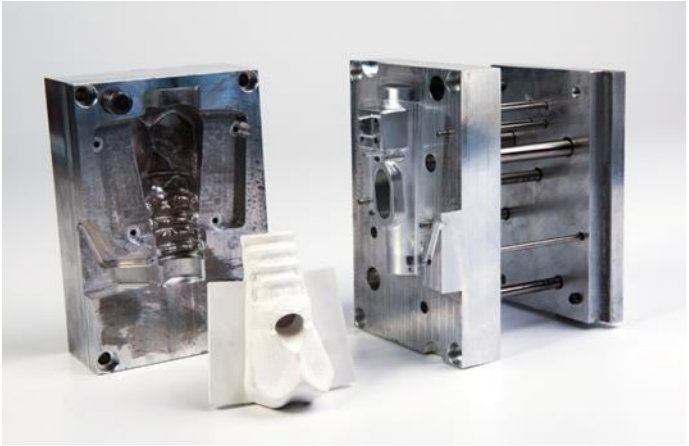
300 + Types of Polymer in Inventory

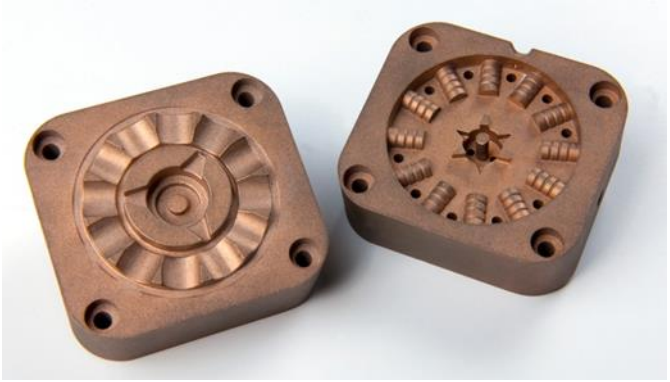
- Engineering Resins with superior performance characteristics
  - ABS, Nylon, Polycarbonate
  - Bioresins: bioorigin, reclaimed, biodegradable
  - Chemical-resistant: Isoplast™
  - Filled: carbon, glass, metal, mineral
  - High-density: EcoMass™
  - High-heat: PEEK, Radel™, Stanyl™, Ultem™
  - Thermally-conductive: electric and dielectric
- Metals
  - Xyloy™: injection-moldable Zinc-Aluminum Alloy

HARBEC INC
TECHNICAL INNOVATION WITH ENVIRONMENTAL RESPONSIBILITY

MOLD MANUFACTURING

- Full In-house Capabilities
  - Design
  - Production
    - Two Shifts
    - Large Toolmaker Team
    - Broad Subcontractor Base
  - Maintenance and repair
- Dedicated Sampling Team
  - Material Trials
  - Fill-time and gate-freeze studies
  - De-bugging and initial part run-offs





HARBEC Mold Making

Rapid Prototyping: Part Parameters

Process	Materials	Tolerance (mm)	Size (cm)	Surface Finish
SLS (DTM)	Polyamide, TPE	+/- 0.25	30 x 35 x 42	Fair
DMLS (EOS)	Stainless Steel Titanium Maraging Steel Nickel-Bronze (DM20)	+/- 0.1	20 x 25 x 25	Good
CNC	Plastics: PEEK, Ultem, Stanyl, ABS, Nylon Metals: Steel, Aluminum, Brass, Copper, Titanium, Inconel, Magnesium	+/- 0.075	Open	Very Good
QMS	Engineering Resins (except high temp)	+/- 0.075	7.5 x 30 x 30	Excellent

Rapid Prototyping: Lead Time & Costs

Process	Lead Time[1]	Tool Cost	Part Cost
SLS (DTM)	1 – 2 Days	$0	Low $100s to $1,000
DMLS (EOS)	1 – 2 Days	$0	Low $100s to $1,000
CNC	2 – 7 Days	$500 - $750[2] (optional)	$10 – Low $100s
QMS	2 – 5 Weeks	$1,500 - $20,000	<$1 - $5

NOTES

[1]Lead Time – assumes model file is complete and final.

[2]CNC Tool Cost – for fixturing (not needed for every job).

Additive Manufacturing ~~~ Tool-Less Manufacturing

- Production Quality Parts in Over 40 Different materials
  - Filled materials
  - Engineering Polymers
  - Carbon Fiber
  - Fiberglass
  - Kevlar®
  - Metals

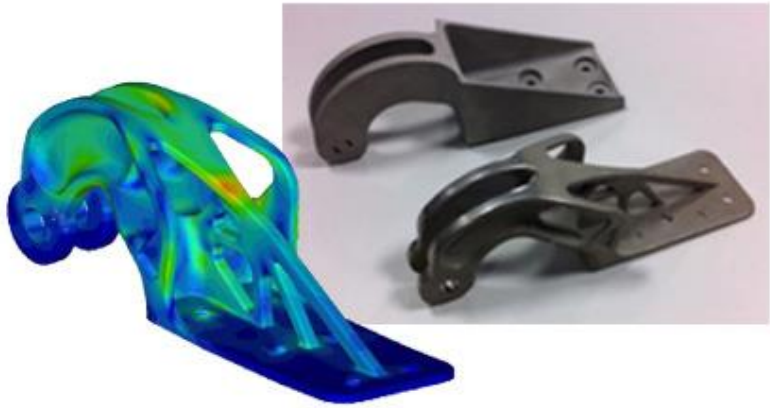
- Additive Manufacturing
  - Stereolithography(SLA)
  - Selective Laser Sintering (SLS)
  - Direct Metal Laser Sintering (DMLS)
  - Fused Deposition Modeling

Additive Manufacturing

HARBEC Development Support

- Part Design Optimization
  - Performance
  - Appearance
  - Manufacturability
  - Topology
- Tool Design
  - Tool Life vs. Tool Cost
  - Tool Cost vs. Part Cost
- Material Specification
  - Cost vs. Performance
  - Supply Risk Mitigation
  - Bioresins = Sustainability

EADS



Mastercam

SolidWorks

Sustainable Manufacturing

In 2013 HARBEC achieved Carbon Neutrality and by the end of 2015 we will achieve Water Neutrality.

*Our **investments** in operational excellence result in tangible cycle time reductions, speed to market, and quality **benefits to our customers**.*

Operational Excellence

Management Systems & Governance	Tools, Policies, Technologies	Energy Generation, Innovation, Leadership
• ISO 9001 • ISO 14001 • ISO 50001/SEP Platinum • Environmental Policy	• Facility level energy management system • Sustainable building design • Green transportation fleet • Energy efficient equipment	• Wind • Geothermal • CHP/Co-Gen • Energy Efficiency • 60% of total energy needed at HARBEC comes from TWO On-site wind turbines

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