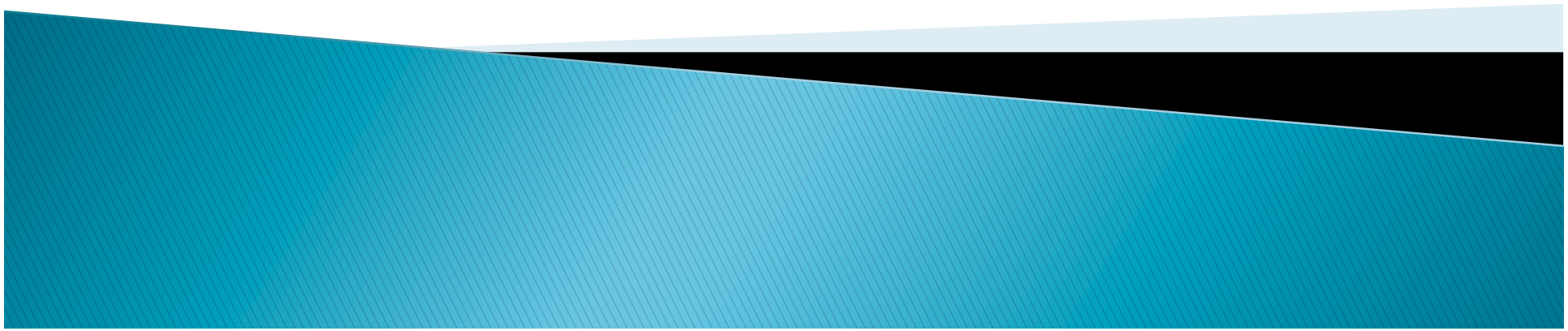
PINNACLE SALES
SERVICE ABOVE THE REST

Lessons Learned

On the road to converting metal to plastic

Michael Kole
Pinnacle Sales, LLC



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Scope

- Marketing & Sales Agency
  - Sales Representation
  - Marketing Plans
  - Product Development
  - Business Coaching & Training
- Specializing in engineered components such as;
  - Fuel pumps & systems
    - Turbine, Gerotor, and Screw Pump technology
  - Water & Oil pumps
  - Electronic Throttle Body
    - Housings & Complex Covers
  - ABS Brake Systems
  - Electronic Control Units
    - Housings & Connectors
  - Compliant Pin Technology

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Principals

- Helvoet Rubber & Plastics
  - Belgium, Holland, India
  - Thermoplastic, Thermoset, and Rubber Precision Parts
  - www.helvoet.com
- Microplastics Inc.
  - St. Charles (Chicago), Illinois
  - Precision insert molding
  - Compliant Pin
  - www.microplasticsinc.com
- Leistritz
  - Nuremberg, Germany
  - Screw Pump Technology
  - www.leistritz.com
- iNMAR
  - Detroit Area
  - Advanced Product Development Firm
    - From Napkin to the Assembly Line

Helvoet

Microplastics
Insert Molding Engineered for Quality

Leistritz

iNMAR

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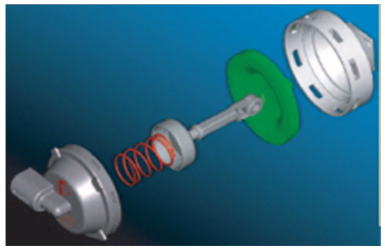
Helvoet



Vacuum Actuators

Electronic Throttle Body's and Air Control Valves

Fuel Pump Chambers

Vacuum Connectors
Custom Check Valves

Thermostat Housings

Hydraulic Solenoid Housings

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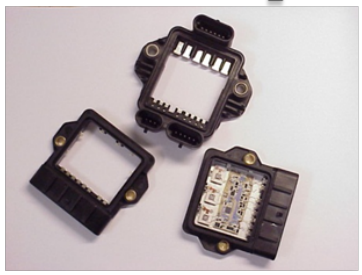
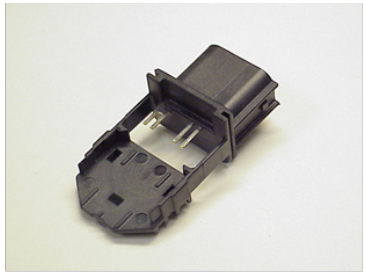
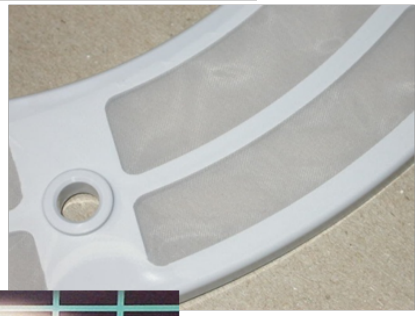
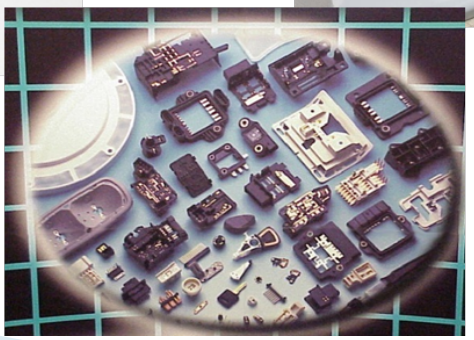
Microplastics









Precision Insert Molding

- *ETC Covers*
- *Sensors*
- *Filters*
- *Compliant Pin*

Complex Products

- *Lead frame development*
- *Cure in place gaskets*
- *Product development*
- *Automated Assembly*

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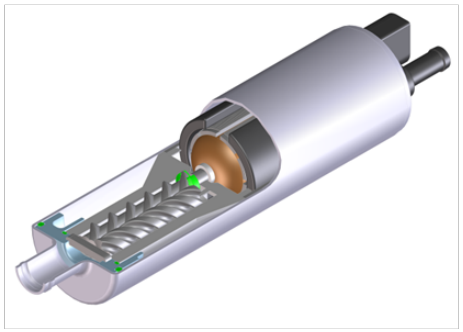
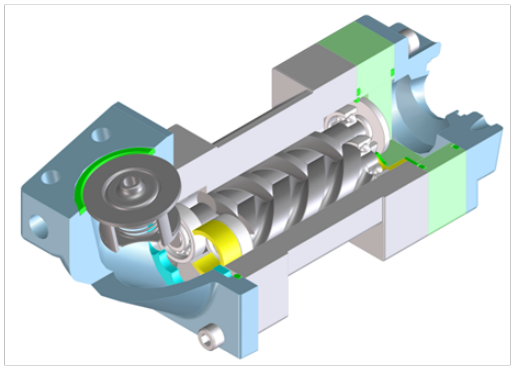
Leistritz





- High Efficiency pumping chambers for
  - Diesel Pumps
  - Gasoline Systems
  - SCR Systems
  - Precision Dosing
  - Metering Systems
- Efficiency
  - >60% for Screw Pump Technology
    - Compare to 20-24% for Turbine & Gerotor

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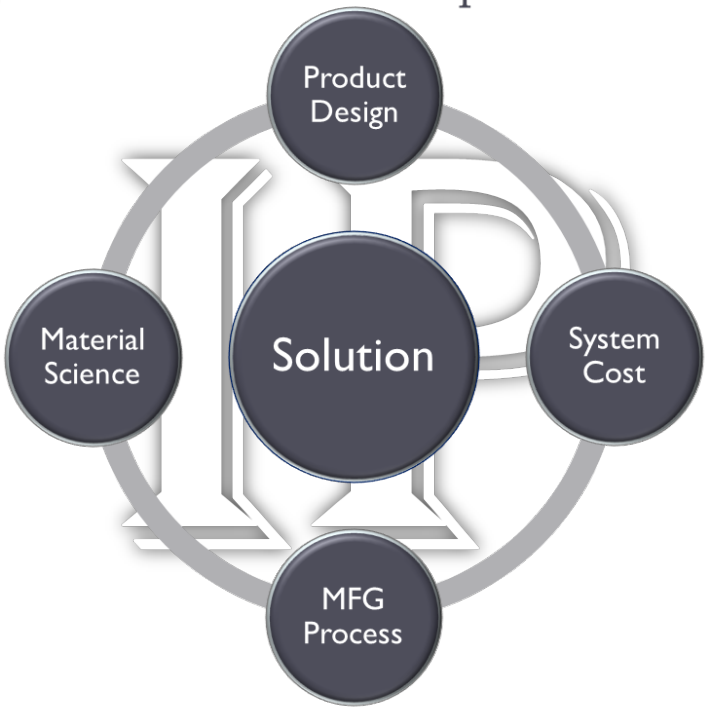
iNMAR

- Product Design
- Material Science Development
- Manufacturing Process Selection and Development
- System Cost Monitoring
- Intellectual Property Generation

Integrated Product Development Process



The fastest route to new product development failure is to focus on one critical area at a time

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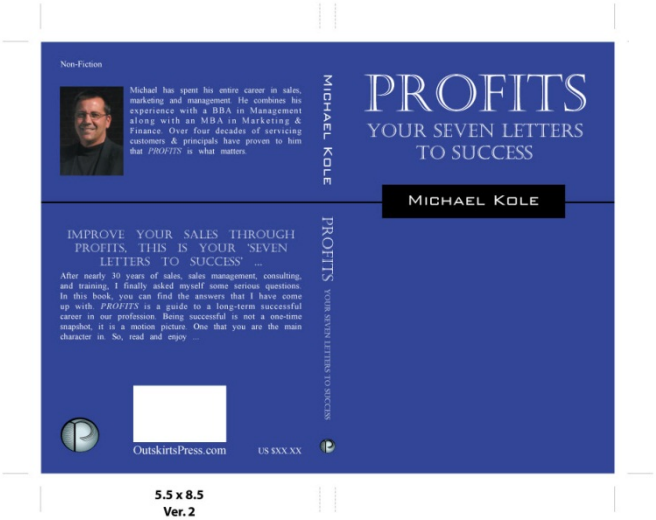
Coaching & Training

Building Credibility



5.5 x 8.5
Ver. 2

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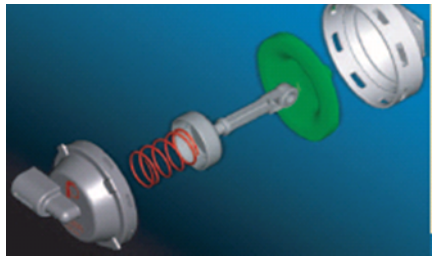
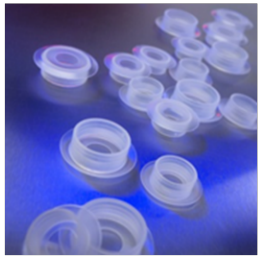
Product Focus



- Powertrain Components
  - Composite Throttle Body
  - Fuel Systems
  - Vacuum & Turbo Actuators
  - Vacuum Systems, Custom Housings & Connectors



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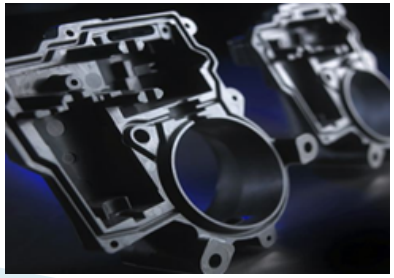
History of Composites

- Introduced in 1990's, mainly thermoplastic materials; PEI, PPA, PPS, PBT
  - Mechanical Throttle Bodies
- Electronic Throttle Body proliferation began
  - Thermoplastic materials could not meet the dimensional challenges
    - Roundness, True Position
- Early 2000's - BMCI Thermoset material chosen
  - Best in class material for;
    - Cost, Dimensional stability, weight reduction & application feasibility
- BMCI/Tetradur introduction of a **"0" Shrink Material**



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Preferred Materials

- BMCI / Tetradur
  - L4220-776
- Key Elements
  - Post Shrinkage 0%
  - Flex Modulus 12 MPa
  - CLTE (comparable to Al)
  - Water Absorption (very low)

All leading to high dimensional stability for process & life of product

tetra-DUR Kunststoff-Produktion GmbH

Dat. 23.01.2004 | Formular-Nr. | Seite 1

TECHNICAL INFORMATION

TETRADUR L 4220 - 776

Description:
Glass fibre reinforced polyester-(UP)-molding compound (BMC). >UP-(MD59+GF20)<
Low Profile formulation with very dark but not homogeneous color.
Especially suitable for parts with low tolerances.

Processing:
Especially suitable for injection molding.
Preferred mold temperature: > 140°C.
Shelf life: 3 month at max.20°C

Properties:

Density	ISO1183	g/cm3	2,0
Shrinkage	ISO 2577	%	ca. -0,02 (elongation)
Post shrinkage	ISO 2577	%	none
Flexural strength	ISO 178	MPa	110
Flexural modulus	ISO 178	MPa	12.000
Impact strength	ISO 179	kJ/m^2	35
Notched impact strength	ISO 179	kJ/m^2	35
Compressive strength	ISO 604	MPa	150
Tensile strength	ISO 527	MPa	40
Thermal expansion	VDE 0304/T.1	$10^{-6}K^{-1}$	ca. 18
HDT - A	ISO 75	°C	> 250
Inflamability	UL subject 94	class	HB
Water absorption	ISO 62	mg (1d)	< 40
Surface resistivity	IEC 60093	Ω	10^{12}
Volume resistivity	IEC 60093	Ω cm	10^{14}
Dissipation factor	IEC 60250		< 0,05
Dielectric constant	IEC 60250		ca. 4,5
Electric strength (1mm)	IEC 60243	kV/mm	20 - 30
Tracking resistance	IEC 60112	CTI	600
Glass transition temperature	DMA	°C	185
Tensile rupture strain	ISO 527	%	0,3
Poison's ratio	ISO 527		0,3
Outer fiber strain	ISO 178	%	1,2

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Programs & Partners

PEUGEOT

Continental

CONTINENTAL

YSLER

MINI

DODGE

VIPER SRT 10

BOSCH

jeep

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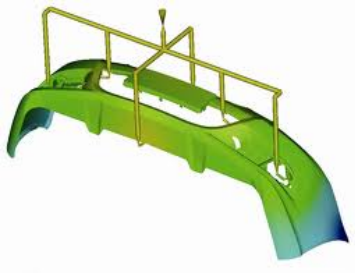
Initial challenges

- ETC's were originally designed for aluminum, not plastic
  - Tolerance, Application Requirements, Durability
- Unable to predict the material flow
  - Knit lines, proper gating, hot spots
  - Unable to identify internal porosity
- Questions on mounting (torque, inserts, creep)
- High Level of Scrap
- Unacceptable cycle time



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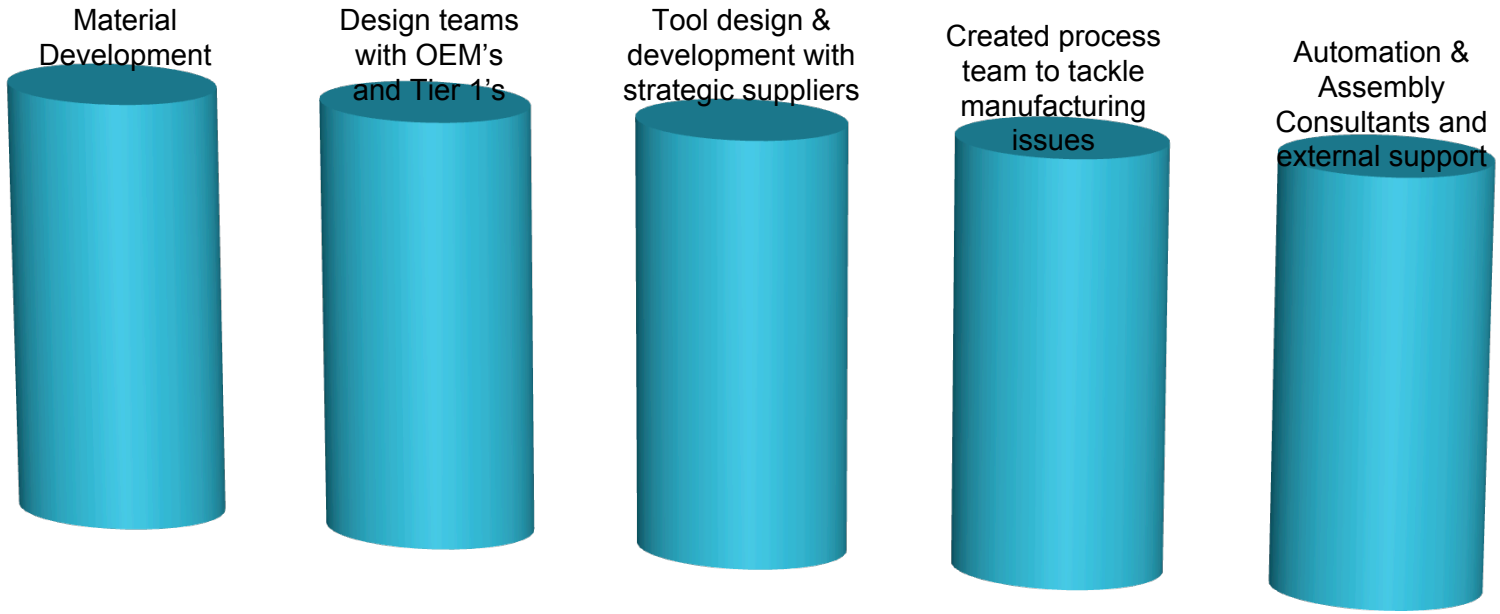
Improvement Teams



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Helvoet specific projects for improvement

- Partnered with BMCI to develop an improved material
  - Higher flow & more consistency batch to batch – PREDICTABILITY
  - Developed with the support of BMC & Corex Software highly accurate Mold Flow Analysis
- Combined efforts with our Tier 1 customers to develop and understand design rules for;
  - Application requirements, molding parameters, strength and assembly issues
  - Answered questions about what the application needs, not what aluminum can do
- Developed a strategic supply base for tool design & development
  - Created exclusive cooling, cleaning, and vacuum systems
  - Implemented cold runner design
  - Initiated aggressive PM and developed special coatings to extend tool life
- Formed internal team to define a robust molding & manufacturing process
  - Reduction of cycle time by over 40%, elimination of handling damages, placement of pressure sensors, and closed loop processing reduced scrap by 80%
  - Developed extensive math models and improved predictability leading to high capability
- Working with outside specialists for automation,
  - Designed and implemented; automated system to reduce burr and surface porosity
  - Critical leak testing procedures
  - Qualified vendors for fastening and developed specifications for mounting

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Tensile rupture strain	ISO 527	%	0,3
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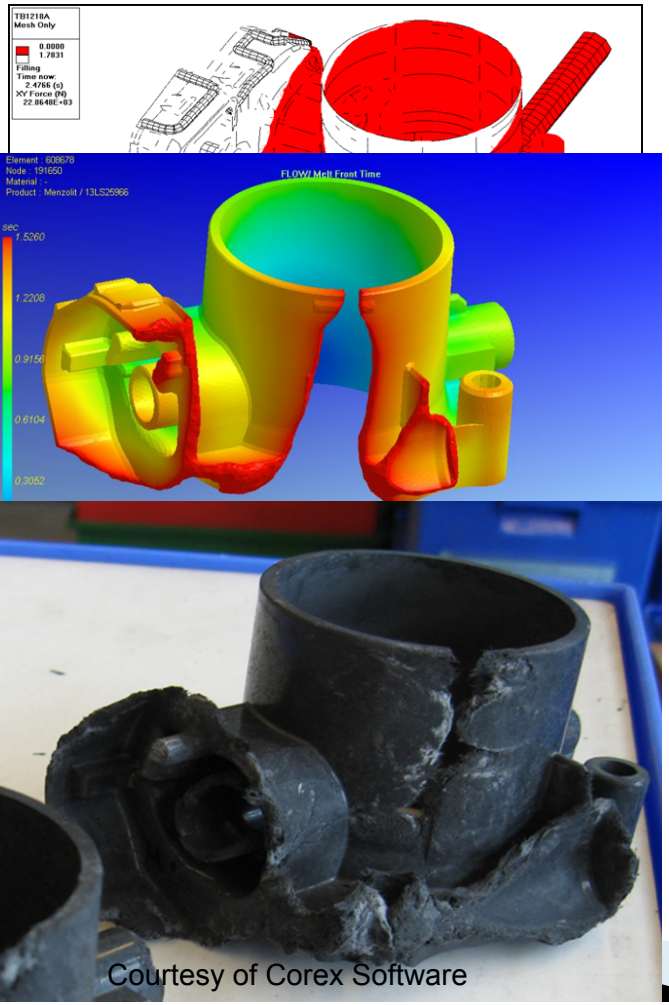
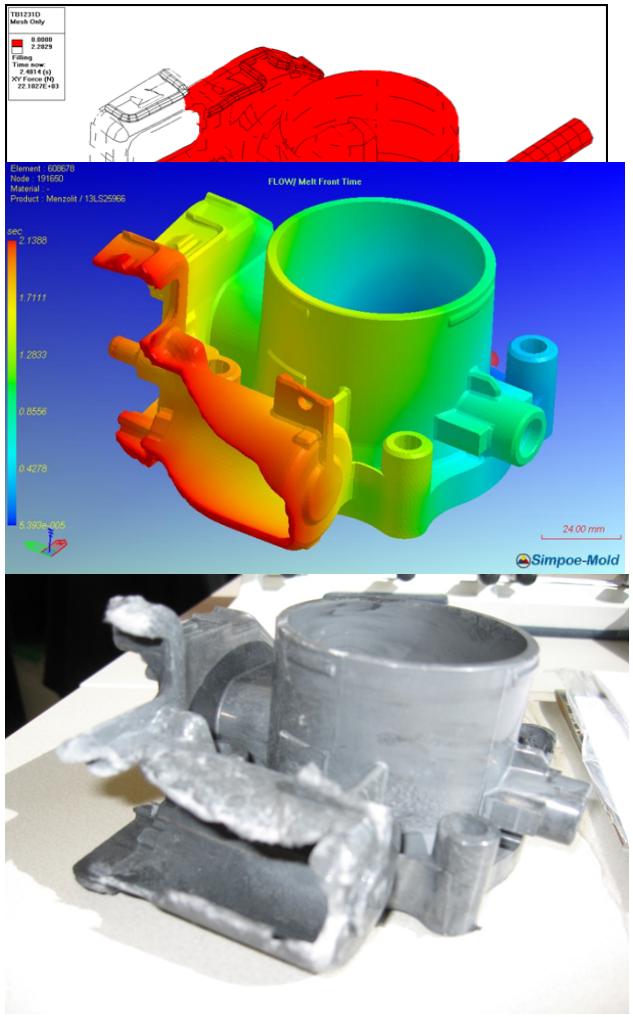
Using technology for predictability

2004 - 2011





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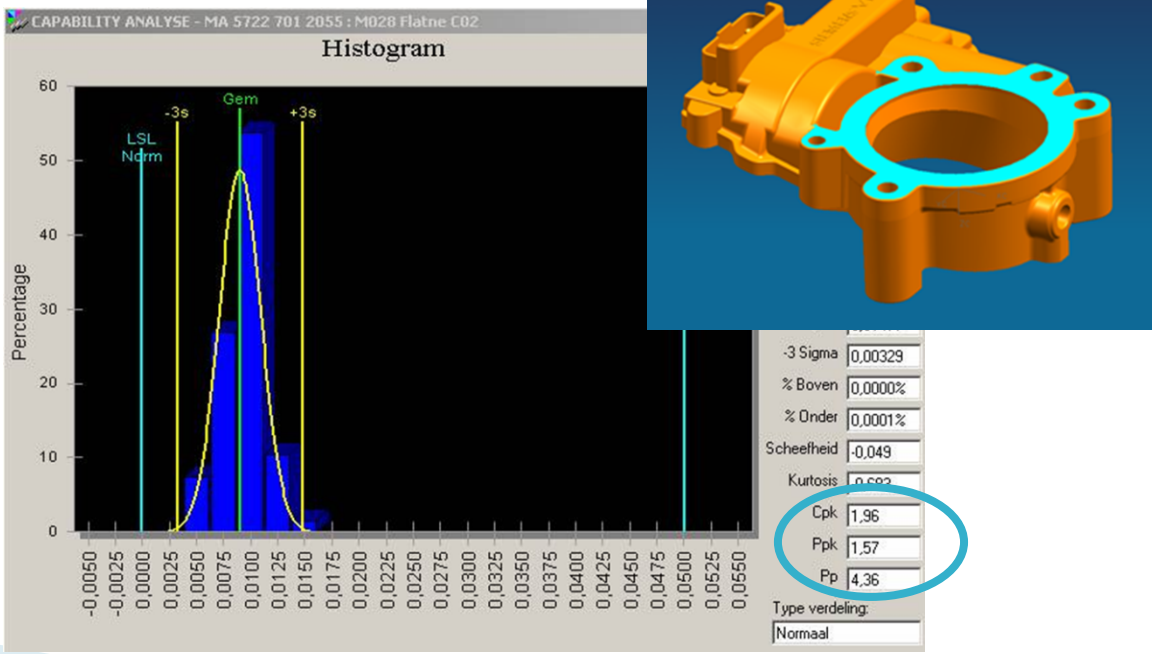
Predictability leads to higher accuracy ….

- Flatness: 25 µm’s (+/- 3 Sigmas)



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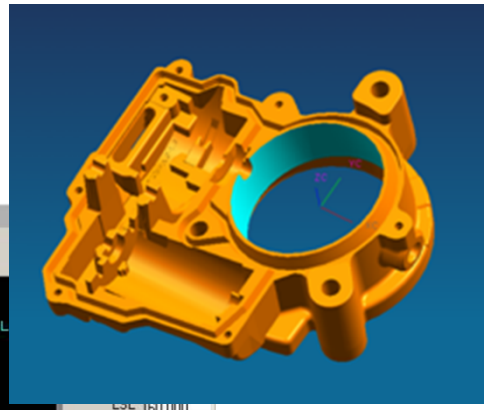
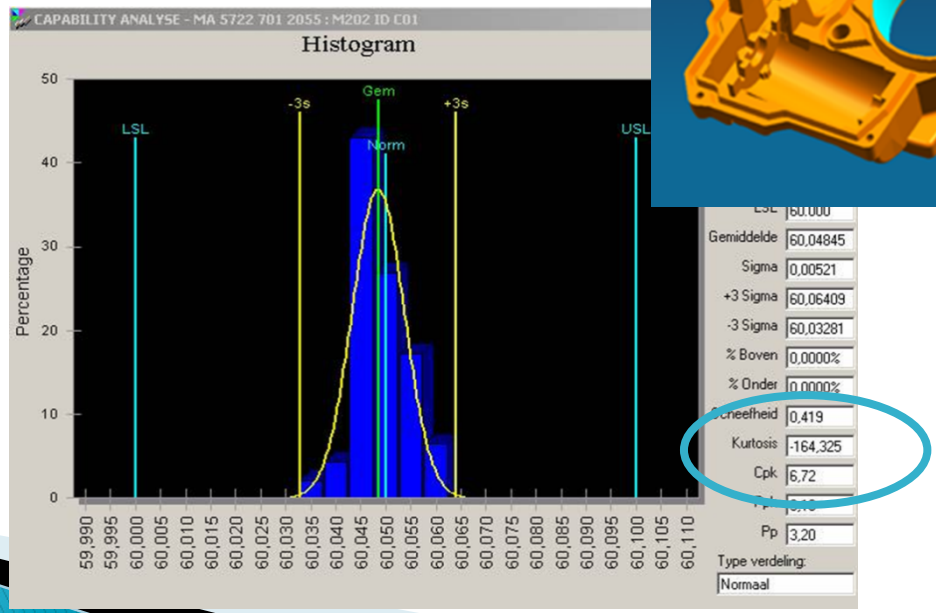
Predictability leads to higher accuracy ….

- Bore Diameter: 60.05
  - 1.67 Cpk = +/- 0.030





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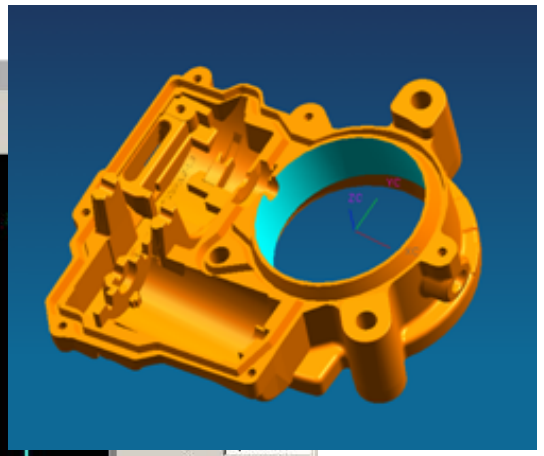
Predictability leads to higher accuracy ….

- Roundness: 30 µm's



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Collaboration with OEM's and Tiers produced application requirements, leading to guidelines …

- Max torque on mounting holes
  - > 20Nm
- Unequal wall thickness is okay
  - Allows for strengthening areas
    - Mounting bosses for example to eliminate compression limiters
    - Transitions from 3mm to 9mm
- Tg 190º C
- Design with tolerances in mind
  - Bore diameters < 84mm
    - +/- 3 Sigma; 35µm's
  - Roundness
    - +/- 3 Sigma; 30µm's
- Flatness for mounting & sealing surfaces
  - 25µm's

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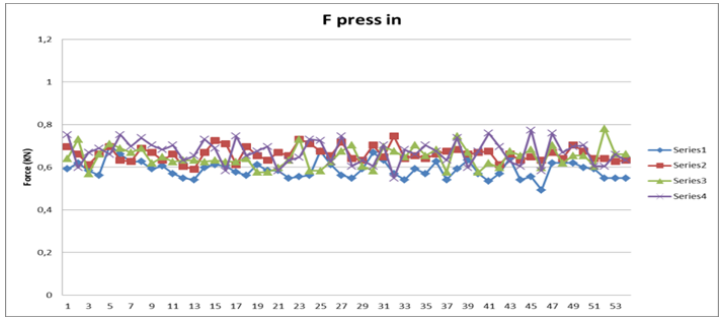
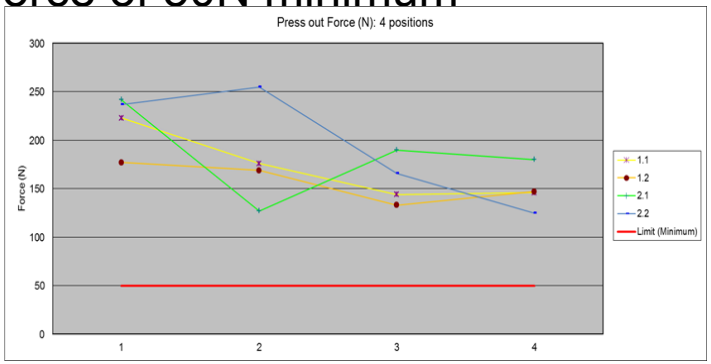
Guidelines…

- If compression limiters are not designed out of the housing …
  - Use crush ribs with a press in force of 400N–900N



  - Press out force of 50N minimum



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Guidelines *(attachments)*

- Ejot self tapping screw in BMC
  - Design rules:
    - Hole diameter = 0,8 x d1
    - Tread length= 2 x d1
  - Experience of our BMC supplier: Ejot Delta PT 4mm
    - Optimal inner diameter: 0,83 x d1 = 3,32 mm
    - Recommended length: 3 x d1 = 12 mm
    - Max Torque:
      - 5,5Nm +/- 0,7 Nm needed to tap the thread
    - Max Clamping force: 3,1 KN

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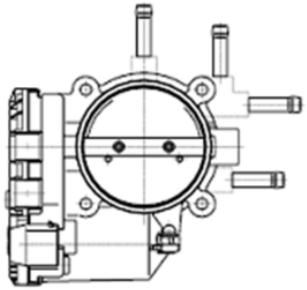
Advantages of Composite Housings

- Weight Savings
  - 15-25% Compared to Aluminum
  - Lower Vibration Stress on the Manifold
- Function integration & increased design freedom
- Crash Performance:
  - Energy absorption in crash testing
  - Engine design – OK for Above Beltline Locations
- Noise reduction
  - Lower vibration = less noise
  - Less stress on manifold, cost can be reduced in this area

EGR



Vacuum

Cooling

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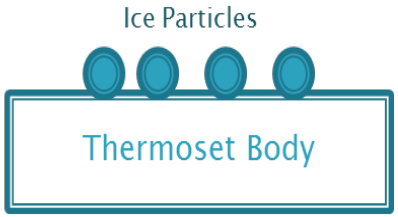
Advantages of Composite Housings

- No Icing issues
  - Lower CLTE
  - No Water Heating Necessary
  - Lower system costs
  - Simplification of control system, downsize of electric motor
  - No ice break system required in controller
- Chemical resistance
- Shorter process flow in comparison to alum
- Longer tool life
  - Significant improvement ratio of tooling investment over tool life
- Price reduction,
  - Up to 25% savings compared to aluminum

- Difficult to remove without using ice breaking in system
- Slow melting point due to high temp transmission of Al



- Very easy to break away
- Fast melting point due to low temp transmission of plastic

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Continuous Improvement

Item	2005	2006	2007	2008	2009	2010	2011	Future
Cycle Time								
Tool life								
Bore Tolerance								
Roundness								
Scrap								
Price	€ 3.90							€ 1.99

Dimensions in Millimeters
Based on Thermoset Housing ~ 250 grams

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Summary

- Composite throttle bodies have proven themselves as a robust solution
  - Over 10 Million housing parts installed
- Financial advantages can significant
  - Component costs lower than aluminum
  - Systems costs lower
  - Roadmap to further savings is defined
- Regardless of intended assembly location, Helvoet can offer localization opportunities
- It took 30-years to get aluminum housings to today's precision
  - The evolution of the composite throttle body has caught up in less than 7 years!

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Offer …

Interested companies please contact …

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mkole@pinnaclesales-llc.com