SMC Premier Class A Parts – Innovation in Process Technology

6th-Annual SPE Automotive Composite Conference
Troy, MSU
September 12th-14th, 2006
Outline - 1

Fully automated SMC-manufacturing line for the production of the VW EOS trunk lid

- Technology development for minimisation of SMC-cut-offs and reduction of part rework, particularly after painting process
- Reproducible process steps
- SMC-Coils to minimize edge trimmings < 10 mm.
- Flow-optimized precut blank and packetting of blanks
- CNC-scale for weight tolerances < 1%.
- Gripping system for Class A surface adequate blank handling
- Hydraulic high speed presses with active parallelism control and vacuum / IMC assisted molding
- Finishing of parts utilizing CNC controlled milling/drilling units and waterjet cutting units
- Data acquisition and documentation of the whole process chain – superset line control
ADVANCED SMC

A new thermoset material for structural applications and class A surface parts

DUROVISION

“DIRECT SMC”
Development goal:
Process development for the reproducible in-line generation of a long fiber reinforced thermoset material in the part manufacturing compression molding process
Fully Automated and Process Monitored Manufacturing of a SMC-Trunk Lid

VW Cabriolet
EOS

SMC trunk lid
INAPAL PLASTICOS S.A., Portugal

System supplier for the fully painted and assembled SMC EOS trunk lid
Fully Automated SMC-Compression Molding Manufacturing Cell
Birds View
Fully Automated and Optimized Manufacturing Cell for the Manufacturing of Class A SMC Trunk Lids
Automated Manufacturing of SMC Class A Outer Shell and Structural Inner Shell
SMC-Coil Handling and Material Provision

Minimization of edge trimmings

- Delivery of large coils
- Washer disk
- Middle cut separation and package winding
- Contouring control
- Barcode-Identification
SMC - Large Coil Separation – Material Provision
SMC – Small Coil Material Provision

Minimization of edge trimmings

- Encapsulated uncoiling unit
- Washer disks for minimization of styrene emissions
- Contouring control for minimization of edge trimmings (Goal: < 5 mm) and therefore significant reduction of SMC waste and additional material cost saving
- Transfer of barcode of semi-finished material into superset line control for continuous quality assurance and documentation
SMC – Small Coil Unit

Adaptation of pre-cut blank to part geometry

Programmable pre-cutting and geometrical adaptation of pre-cut blanks by positioning and stacking of blanks
Determination of SMC-Charge Weight

Small weight tolerances

- CNC-scale
- Weight tolerances < 1 % (total stack of blanks)
Material Handling Unit for Class-A Exterior Body Panels

Special gripping unit

- Preforming of SMC-Charge
- Cleaning unit for mold
Reproducible Manufacturing Process

- Total time of exposure < 25 s
- Minimization of pressure-free residual time of SMC in mold
- Total closing time inclusive high speed closing as well as velocity profiled and pressure profiled closing
- Minimization of semi-finished material usage
- Flow optimized compression molding of the part.
- Vacuum venting
- IMC-application
SMC-Press Requirements for a Process Optimized SMC Processing

CNC-controlled compression molding

Closing velocity:
- Rapid motion: max. 1200 mm/s
- Compression molding: 1 – 80 mm/s

Press opening:
- Prize opening of mold: 0.5 – 80 mm/s
- Rapid return: max. 1200 mm/s

Pressure build-up: < 0.4 s

Total compression molding time: < 4 s

Accepted deviation of parallelism at maximum excentric momentum

<table>
<thead>
<tr>
<th>Press velocity [mm/s]</th>
<th>Max. parallelism deviation [mm]</th>
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<td>1</td>
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Dimensional Stability for Secondary Finishing

Post-cooling section – defined fixation of the part
Secondary Finishing of Class A Outer Shell
CNC-Machining Center
Secondary Finishing of Structural Inner Shell Waterjet Cutting Unit
Manual Deflashing of Structural Inner Shell
Control Unit of Manufacturing Cell
Production Line and Quality Control

- Batch uniformity
- Reproducibility of processing
- Part weight
- Part geometry
Production- and Quality Control

- Progression of manufacturing process (process stability)
- Part related statistic analysis of recorded process parameters allocated by barcode printer
- Automated reject of scrap parts
- Determination and display of cpk- and cmk Values

Evaluation of process data - Gaussian normal distribution

Trend display during processing
Advanced SMC – New Material in an Innovative Process

- High tensile strength by co-molding of continuous carbon fibers (sheet)
- Chopped fibers for perpendicular reinforcement and reduction of anisotropy
- Stacking and engineered build-up of thin layers (stiffness-optimized) after semi-finished material sheet production and maturation

Joint development of a new material and process based on standard SMC processing for the manufacturing of carbon fiber reinforced automotive components

Development team:
- Menzolit-Fibron GmbH
- DaimlerChrysler AG
- Volkswagen AG
Manufacturing of Semi-Finished Sheets

Source: Menzolit-Fibron
Potential Weight Savings

- CFRP 50% Carbon fibers: 31%
- SMC (LP): 63%
- AdvancedSMC°: 39%
- Aluminum ALMgSi1 F32: 50%
- Steel St 1402: 100%

Source: Menzolit-Fibron
Tensile Properties

Advanced SMC: Tensile strength MPa

- Unidirectional
  - "Isotropic": 347 MPa
  - Surface: 464 MPa

- Standard SMC: 88 MPa

Source: Menzolit-Fibron
Trunk Lid – Structural Inner Shell

For demonstration purposes only

Source: Menzolit-Fibron

Picture: DaimlerChrysler
Trunk-Lid Class A Outer Shell

Source: Menzolit-Fibron
Assembled Engine Hood

Source: Menzolit-Fibron
Demonstrator Part – Engine Hood

Source: Menzolit-Fibron
First Application in Series-Production

Rear parcel shelf of Mercedes Benz SLR McLaren

Source: Menzolit-Fibron
Summary

- High material costs due to costs for carbon fibers
- Weight savings compensate material cost to a little amount
- Wall thicknesses of 1.3 mm to 1.8 mm are possible
- It is expected that costs of carbon fibers will decrease if market grows significantly and enough capacities for production are available
- Today process efforts for handling, compression molding and secondary finishing are higher compared to alternative processes for the processing of carbon fibers
- Existing compression molding equipment can be utilized
- Significant weight reduction for ultra-light vehicles.
BMBF Durovision

„Innovative Material Development for the Manufacturing of Light Weight Thermoset Composite Parts“

Reference number: 03X3000

Fraunhofer Institut Chemische Technologie
Goals of the Development

- **Development of a direct-SMC – Fiber Molding Compound (FMC)**
  Dosing and homogenisation of raw materials, incorporation of chopped fibers and compression molding of parts are forming an integrated process chain

- **Constant and reproducible quality for premium applications (Class-A)**
  by just-in-time production and abolition of multi-days maturation time efficient process control is obtained

- **Reduction of part costs**
  by reduction of number of raw material necessary, by reduction of processing steps and secondary finishing steps as well as minimization of production waste and cycle time

- **Reduction of cycle time**
  by fully automated part manufacturing in a direct process in combination with a suitable material development utilizing microwave for an accelerated maturation

- **High flexibility**
  by independence in material formulations and incorporation of amount and type of reinforcements
Process Layout (schematic)

- Liquid components
- Fillers
- Resin preparation
- FMC Compounding
- Chopped fiber dosing
- Microwave accelerated maturation
- FMC discharging
- Part manufacturing
Summary and Outlook

A continuous and consequent improvement of all process steps as well as of the material formulations of the existing SMC technology is necessary to realize a FMC direct process.

The success of the described project will lead to an expansion in use of thermoset composites for compression molding.
Thank you very much for your attention