Coatings and Process Development for Reduced Energy Automotive OEM Manufacturing

DE-EE0005777

PPG, Dürr Systems USA & North Dakota State University
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This presentation does not contain any proprietary, confidential, or otherwise restricted information.
Project Objective

- Develop coatings, processes and facility design to reduce energy consumption in automotive OEM paint shops

70% of the automotive assembly plant energy is consumed in the paint shop

- Technical Barriers
  - Maintaining coating properties at lower temperature cure
  - Low temperature cross-link chemistries not commercial
  - Adoption of waterborne technologies and VOC restrictions
  - Process optimization compatibility with “Brownfield” conversion
Technical Innovation – Conventional Process

Body in white

- Phosphate/Pretreatment
- Electrocoat
- Liquid Applied Sound Deadener
- Sealer Application
- Electrocoat Oven 20’ x 170°C
- Dry Sand
- Primer Application
- Primer Oven 20’ x 150°C
- Prime Sand
- Solvent Wipe/Tack Off
- Solvent Clearcoat
- BC prebake 5’ x 80°C
- Traditional Basecoats
- CC Oven 20’ x 140°C
- Spot/Metal Repair
- Inspection Booth
- Repro Stand
- Solvent Wipe/Tack Off
- TRIM

**Body in white**

- Phosphate/Pretreatment
- Electrocoat
- Dry Sand
- Liquid Applied Sound Deadener
- Sealer Application
- Electrocoat Oven 20’ x 170°C
- Solvent Clearcoat
- BC prebake 5’ x 80°C
- B1:B2 Compact Process Basecoats
- CC Oven 20’ x 140°C
- Spot / Metal Repair
- Inspection Booth
- Repro Stand
- Solvent Wipe / Tack Off
- TRIM

Energy Savings – 30%
CO₂ Reduction – 43%
VOC Reduction – 7%
Cycle Time Reduction – 15 minutes

BMW Spartanburg
Technical Innovation – Reduced Energy Process

- Lower Oven Temperature
- Reduction in Waste Heat
- Faster Time Between Layer Applications
- Lowers Fresh Air Demand in Oven

- Reduced Temperature/Humidity Control Requirements
- Enable Lightweighting – Temperature Sensitive Substrates
Technical Approach – Low Temperature Cure

Low Temperature Cure Coating

• Development of new low temperature cure polymers and formulas
  • Oven temperature reduction $140^\circ C \rightarrow \leq 100^\circ C$
  • Dehydration redesign for smaller footprint, lower energy

• Target layers include; Primer, Basecoat and Clearcoat

• North Dakota State University: High-throughput material analysis

• Dürr Systems Inc.: Application system modeling, design, and fabrication
Technical Approach – Coating System Engineering

• Engineering analysis encompasses
  • Annual energy calculations and costs
  • Capital investment requirements

• Coating System Equipment
  • Applicator design and control
  • Spray booth system – housing, air handling units, particulate scrubber, automation
  • Oven and inter-coat flash/dehydration system – heating and cooling equipment
  • VOC abatement equipment – solvent based spray zones and cure ovens
## Technical Approach – Coating System Engineering

### Baseline 2 - FP-BC-CC Compact Painting Process

<table>
<thead>
<tr>
<th>Process</th>
<th>Flash</th>
<th>Cooler</th>
<th>Flash</th>
<th>Cooler</th>
<th>Flash</th>
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<tbody>
<tr>
<td>B/C 1 w/b Exterior</td>
<td>B/C 2 w/b Interior</td>
<td>B/C 2 w/b Exterior 1</td>
<td>B/C 2 w/b Exterior 2</td>
<td>Amb Flash</td>
<td>Heated Flash 77°C</td>
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<td>Amb Flash</td>
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</table>

### Baseline 1 - B1-B2-CC Painting Process

<table>
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<td>B/C 2 w/b Exterior 1</td>
<td>B/C 2 w/b Exterior 2</td>
<td>Amb Flash</td>
<td>Heated Flash 70°C</td>
<td>Cooler</td>
<td>C/C Interior</td>
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### Compact the process further

**PPG 1 Alternate Process**

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<td>Cooler</td>
<td>C/C Interior</td>
<td>C/C Exterior 1</td>
<td>C/C Exterior 2</td>
<td>Amb Flash</td>
<td>Cure Oven 80°C</td>
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**PPG 2 Alternate Process**

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</thead>
<tbody>
<tr>
<td>B/C 1 w/b Exterior</td>
<td>B/C 2 w/b Interior</td>
<td>B/C 2 w/b Exterior</td>
<td>Heated Flash 70°C</td>
<td>Cooler</td>
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<td>C/C Exterior 1</td>
<td>C/C Exterior 2</td>
<td>Amb Flash</td>
<td>Cure Oven 80°C</td>
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**PPG 3 Alternate Process**

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<td>Amb Flash</td>
<td>Cure Oven 80°C</td>
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Transition and Deployment

- Automotive Industry

  PPG Innovations
  - Cationic Electrodeposition
  - Powder Clearcoat
  - B1:B2 Process

- Enable application temperature sensitive substrates and lightweighting

- Staged commercialization to manage risk
  - Low temperature application on existing lines
  - Monobooth conversion in target plant
  - Implementation dependent on automotive facility capital depreciation plans
Measure of Success

- Development of low temperature cure topcoat systems that meet stringent automotive performance properties
- Lab scale prototype validation of a consolidated topcoat booth design and associated energy saving
- OEM briefings are included in budget period go/no-go decisions and final deliverables
- Identification of an OEM partner planned for continued development and commercialization

- Project proposal identified 18 TBtu/year savings based on 2012 US vehicle projection
  - Project on track to meet these goals based on BP1 achievements
  - Dürr Systems quantified energy savings of material and process improvements relative to current baseline
Project Management & Budget

Develop low temperature cure polymers and formulas

BP1
- 15 Mo
- Jan15-Mar16

BP2
- 11 Mo
- Apr16-Feb17

BP3
- 10 Mo
- Mar17-Dec17

Lab scale validation of materials and process

Engineering and manufacture of lab scale booth and oven designs

**Total Project Budget**

<table>
<thead>
<tr>
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<th>DOE Investment</th>
<th>$2,972,349</th>
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<tr>
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<tr>
<td>Project Total</td>
<td>$4,246,071</td>
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Results and Accomplishments

- Met Go/No-Go criteria for BP1
  - Selected 3 low temperature cure chemistries for the BP2 low-temperature coating
  - Cure at 80 °C in 30 minutes
  - Met BP1 goals for performance parameters, on track for whole-project/OEM performance
- Developed high-throughput screening method; evaluated 140 reactions (48 reactions, 12 catalysts, and four reaction times) for percent conversion (NDSU)
- Completed energy usage calculations (Dürr)
  - 39% reduction compared to a no-bake primer process
  - 27% reduction compared to state of the art compact process

Annual Emission Reductions:
- 6.3K lb./yr NO\textsubscript{x}
- 4.6K ton/yr CO\textsubscript{2}

Annual Utility Operating Cost Savings:
- $530K/yr

Capital Cost Savings (Greenfield):
- $5.4MM