Coatings and Process Development for Reduced Energy Automotive OEM Manufacturing

DE-EE0005777

PPG Industries, Inc. / Dürr Systems USA, Inc. & 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 Approach

Low Temperature Cure Coating Systems

- Development of new low temperature cure polymers and formulas
- Five candidate chemistries identified
- Oven temperature reduction 140°C → <100°C
- Target layers include: Primer, Basecoat and Clearcoat

Energy Benefits

- 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 – Conventional Process

Body in white

Phosphate/Pretreatment → Electrocoat

Dry Sand → Liquid Applied Sound Deadener → Sealer Application → Electrocoat Oven 20’ x 170°C

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

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

BMW Spartanburg
Technical Approach

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 30’ x 100°C
- Spot / Metal Repair
- Inspection Booth
- Repro Stand
- Solvent Wipe /Tack Off
- TRIM

- Smaller manufacturing footprint
- Lower energy demand for conditioned air
- Lower capital cost
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 performance property milestones
- 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 for continued development and commercialization

- Project proposal identified 18 Tbtu/year savings based on 2012 US vehicle projection
- Dürr Systems will quantify energy calculations of material and process improvements relative to current baseline
# Measure of Success - Go/No Go Criteria

<table>
<thead>
<tr>
<th>Budget Period 1</th>
<th>Budget Period 2</th>
<th>Budget Period 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Formulation &lt;100°C cure</td>
<td>1) Formulation &lt;100°C cure</td>
<td>1) Formulation &lt;100°C cure</td>
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<tr>
<td>Hardness- 75</td>
<td>Hardness- 100</td>
<td>Hardness- 105</td>
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<tr>
<td>Solvent double rubs – 85</td>
<td>Solvent double rubs – 100</td>
<td>Solvent double rubs – 100</td>
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<td>Longwave – 25</td>
<td>Longwave – 15</td>
<td>Longwave –12</td>
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<td>Shortwave - 35</td>
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<td>Flop index – 7.0</td>
<td>Flop index – 8.5</td>
<td>Flop index – 9.5</td>
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<td>DOI – 65</td>
<td>DOI – 80</td>
<td>DOI – 85</td>
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<tr>
<td>2) OEM project briefing</td>
<td>2) OEM project briefing</td>
<td>2) OEM project briefing</td>
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<tr>
<td>3) Process conditions</td>
<td>3) Process validation</td>
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</tr>
<tr>
<td>Fluid delivery rates equal current range</td>
<td>Full scale body panel application demonstrating prototype process and material improvements</td>
<td></td>
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<tr>
<td>Humidity range – 50% - 80%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temp. range - 70°C - 100°C</td>
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Project Management & Budget

**Total Project Budget**

<table>
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<tr>
<th>Component</th>
<th>Amount</th>
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<tr>
<td>DOE Investment</td>
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<tr>
<td>Cost Share</td>
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<td>Project Total</td>
<td>$4,246,071</td>
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</table>

**BP1**
- 15 Mo
- Jan15-Mar16

Develop low temperature cure polymers and formulas

**BP2**
- 11 Mo
- Apr16-Feb17

Engineering and manufacture of lab scale booth and oven designs

**BP3**
- 10 Mo
- Mar17-Dec17

Lab scale validation of materials and process

<table>
<thead>
<tr>
<th>Title</th>
<th>Milestone</th>
<th>Description</th>
<th>Quarter</th>
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<tbody>
<tr>
<td>Synthesis</td>
<td>M1.1.1</td>
<td>Physical data on polymer samples</td>
<td>Q1</td>
</tr>
<tr>
<td>Initial Formulation</td>
<td>M1.2.1</td>
<td>Solid color basecoat/clearcoat application</td>
<td>Q2</td>
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<tr>
<td>Monobooth Coatings</td>
<td>M1.3.1</td>
<td>Metallic color basecoat/clearcoat applications</td>
<td>Q3</td>
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<tr>
<td>Monobooth Process</td>
<td>M1.3.2</td>
<td>Process variables defined</td>
<td>Q3</td>
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<tr>
<td>Combinatorial catalysts</td>
<td>M2.1</td>
<td>Catalyst investigations through combinatorial techniques</td>
<td>Q4</td>
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<tr>
<td>Design Principles</td>
<td>M3.3.1</td>
<td>Coating system design strategies communicated to equipment supplier</td>
<td>Q5</td>
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<tr>
<td>Chemistry Selection</td>
<td>M4.1</td>
<td>Coating chemistry down-selection</td>
<td>Q5</td>
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<tr>
<td>Combinatorial coatings</td>
<td>M6.1</td>
<td>Coating investigations through combinatorial techniques</td>
<td>Q6</td>
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<tr>
<td>Equipment Design</td>
<td>M7.4.1</td>
<td>Oven/booth equipment requirements defined</td>
<td>Q7</td>
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<tr>
<td>Equipment Fabrication</td>
<td>M7.5.1</td>
<td>Fabrication of lab scale equipment</td>
<td>Q8</td>
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<tr>
<td>Equipment Installation</td>
<td>M9.1</td>
<td>Equipment installation at PPG labs</td>
<td>Q9</td>
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<tr>
<td>Lab Scale simulations</td>
<td>M10.1</td>
<td>Demonstration using newly fabricated monobooth concept</td>
<td>Q10</td>
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<tr>
<td>System Optimization</td>
<td>M11.1</td>
<td>Coating systems demonstrated using optimized equipment and materials</td>
<td>Q11</td>
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<tr>
<td>Final reporting</td>
<td>M12.1</td>
<td>Final Reporting for entire project</td>
<td>Q12</td>
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Results and Accomplishments

• Project mobilization complete

• Lab studies of initial low temperature cure coating formulations demonstrating positive results