U.S. DEPARTMENT OF
ENERGY

Office of
ENERGY EFFICIENCY &
RENEWABLE ENERGY

Coatings and Process Development for Reduced Energy Automotive OEM Manufacturing

Few durable goods have the impressive appearance of today's automobiles. But, there is a cost for that finish. The paint shop in automotive assembly plants typically accounts for more than two-thirds of energy consumed at the plant. Of that energy, three-quarters supplies the paint spray booths and paint curing ovens.

Coatings used by original equipment manufacturers (OEMs) require carefully controlled environments for both application and cure to meet quality and appearance standards. Coating applications require controlled booth environments to manage overspray and ensure a consistent coating. Paint curing ovens require elevated temperatures (285°F) and controlled airflow for even heat distribution, all of which contribute to the high energy intensity of the paint shop.

This project combined new chemistries for coatings with new processes designed to take advantage of the novel coating's advanced properties. Each of the chemistries identified for evaluation cured at temperatures well below typical coatings in use today. Furthermore, the chemical process by which the new coating technologies set and harden differs significantly from typical coatings, allowing new processes that require less air conditioning and smaller plant floor footprints.

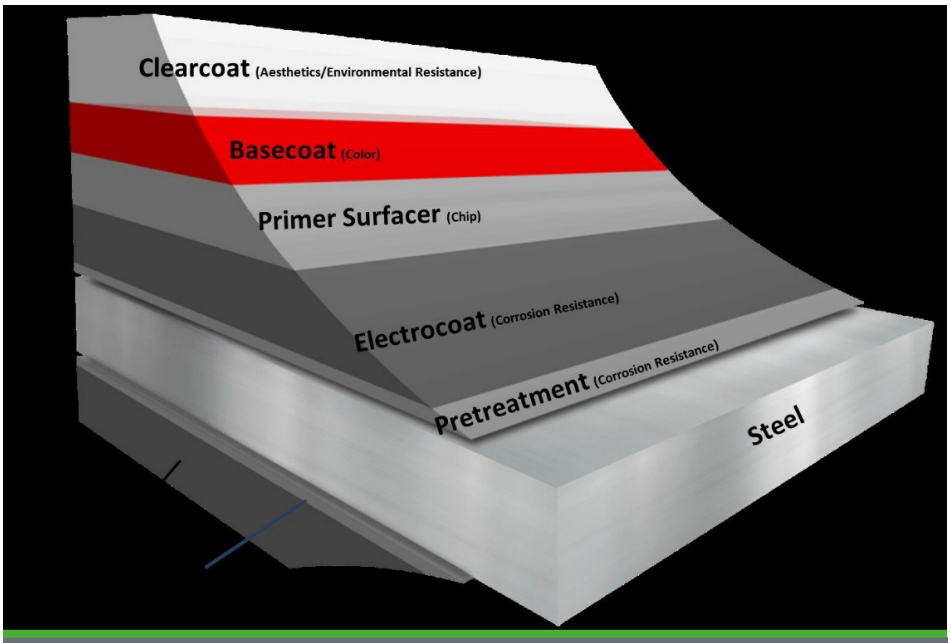

Figure 1. Schematic illustrating the layers of coatings from typical automotive manufacturing processes. This project targets the Primer, Basecoat, and Clearcoat layers.

Graphic image courtesy of PPG Industries, Inc.

Benefits for Our Industry and Our Nation

Reducing cure temperatures through novel coating chemistries and improving coating processes has the following benefits:

- Reduced energy consumption in curing ovens is possible due to lower oven temperature requirements. Improved air flow will also reduce waste heat.
- Reduced time between layer applications can increase productivity for automobile manufacturers, and reduce the plant floor footprint.
- Lower conditioned air requirements reduces the energy consumed by HVAC systems. Similarly, reduced temperature and humidity control requirements allow for less energy consuming air-handling equipment.
- Compatibility with temperature-sensitive materials, such as polymer composites for vehicle lightweighting, will allow the same coatings process for multiple substrates.

Applications in Our Nation's Industry

This technology provides the automotive manufacturing industry with a low-energy method of applying basecoat and clearcoat layers to automotive frames and other original equipment. The technology can be integrated seamlessly into the existing infrastructure, and even reduce the footprint of the paint shop in automotive plants. The chemistries developed are also applicable to a wide range of industrial coatings operations such as appliance, aerospace, and heavy duty construction vehicles.

Project Description

The project objective was to validate a lower energy/higher productivity automotive coating system with the potential to deliver a reduced manufacturing footprint but maintain quality, performance, and appearance. An initial screening of possible chemistries for low cure temperatures, appearance, and adhesion led to a limited set of candidates for further improvement. With characterization of the properties of candidate formulations, researchers then refined the coating application and curing process, with emphasis on engineering solutions for air handling and booth design. The project team investigated the potential to apply the basecoat/clearcoat layers in one "monobooth". Together, the novel materials and processes dramatically reduce energy consumption in the paint shop of automotive assembly plants, while the monobooth concept reduces the footprint of the paint shop on the assembly floor.

Figure 2. The new coating system was successfully developed in three colors: silver, white, and black. Appearance data exceeded the milestone criteria for all three colors.

Photos courtesy of PPG Industries, Inc.

Barriers

- Establishing a polymer formulation that cures at sufficiently low temperatures in a sufficiently short time frame
- Producing a basecoat that maintains proper orientation of the metallic flakes embedded within the basecoat
- Ensuring the novel coatings are not too sensitive to variations in relative humidity in paint spray booths and curing ovens

Pathways

Five different chemistries were selected for preliminary evaluation as low-temperature coatings in automotive applications. The cure response was evaluated at different temperatures, and the appearance and performance properties monitored using American Society for Testing & Materials methods and manufacturer specific testing procedures. This process allowed researchers to down-select potential coating chemistries for further development.

The next stage focused on coating application processes and the monobooth design for promising low temperature cure systems. Finally, researchers further refined the processes developed and worked with the project partner to build a laboratory scale prototype oven. Dürr Systems then estimated the potential energy savings based on the lower operating temperatures.

Milestones

This project began in January 2015 and successfully completed in June 2018.

- Formulated and tested initial polymer samples in both solid and metallic color basecoat/clearcoat applications
- Defined critical process variables and operating parameters (curing temperature, curing times, etc.)
- Selected coating chemistry and identified associated coating system design requirements
- Fabricated and installed lab scale equipment
- Production simulated and coating optimized

Accomplishments

Developed a new low-temperature monobooth coating system that achieves performance, durability, and appearance requirements for an automotive OEM paint system (see Figure 2) that is compatible with current OEM manufacturing paint lines, allowing application to existing manufacturing locations.

The monobooth paint system also:

- Enables capital expense savings for new lines and renovations of existing lines
- Enables energy savings >35% over state of the art as well as operational expense savings

Technology Transition

Both PPG and Dürr Systems USA have established relationships with multiple automobile manufacturers and are actively pursuing opportunities to demonstrate this technology with the large U.S.-based automotive manufacturers. PPG will also continue to invest in the technology to further develop the coating system.

Project Partners

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The final report is available at
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