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Review on Automotive Body Coating Process

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ABSTRACT

Automotive coatings and the processes used to coaat automobile surfaces exemplify the avant-grade of technologies that are capable of producing durable surfaces, exceeding customers expections of apperance, maximizing efficiency, and meeting environmental regulations. These accomplishments are rooted in 100 years of experience, trial-and-error approaches, technique and technology advancements, and theroetical assessments. Because of advancenments directed at understanding the how, why, when, and where of automobile coatings, the progress in controlling droplets and their deposition attributes, and the development of new technologies and paint chemistries, a comprehensive and up-to-date review of automobile coating and coating technologies was considered to be a value to industrial practitioners and researches.

Overall the critical performance factors driving the development and use of advanced automotive coatings and coating technologies are (a) aesthetic characteristics; (b) corrosion protection; (c) mass production; (d) cost and environmental requirements; (e) appearance and durability. Although the relative importance of each of these factors is debatable, the perfection of any one at the expense of another would be unacceptable. Hence, new developments in automotive coatings are described and discussed in the following review, and then related to improvements in production technologies& paints. Modern automotive coating procedure are also discussed in details.

Keywords-- Corrosion, Durability, Color

I. INTRODUCTION

At the beginning of the automotive industry about 100 years ago, cars were painted with a varnish-like product that was brushed onto the vehicle surfaces; this coating was sanded and smoothed, and then varnish was reapplied and refinished to establish several layers of the coating. After multiple layers of varnish were applied, vehicles were polished to produce shiny surfaces. Some manufactures, including Ford in the model T line, employed a combination of brushing, dipping, & even pouring to fully cover and protect various parts of car. All of these coating steps were implemented manually, and it was not uncommon for the period between ht beginnings of the coating process to the end, when the coating was dry and the car was ready to sell, to take upto 40 days. Between the 1920s & 1940s, automotive transitioned to using spray equipment & 'stoving enamels' that were based on alkyd resins; these two advancements decreased application and drying times to a week or less. Because of the newly developed spray coating technologies, the surface finishes were more even & less sanding was needed.

Automotive coatings continue to evolve as they either satisfy or are anticipated to meet customer expectations & environmental regulations while also lowering manufacturing & ownership costs. One of these evolutions is in the use of smart coatings because thet offer the potential to significantly improve surface durability while adding additional functionalities or properties like self-healing, super-hydrophobicity, self-stratifying, self-sensing, sound proofing, & vibration damping. For example, a smart coating could respond to its environment to enhance the coating life; a smart coating with self-healing properties would be useful in response to an abrasive, mechanical trigger or to a corrosive event in which the coating is self-healing as result of UV, heat, or mechanical activation. Self-healing can also be achieved by employing shape memory polymers that are triggered with temperature and humidity manipulations, or with UV radiation; self-healing asscocited with the swelling of special clays such as montorillonite is also possible. Other smart coatings include those with internal sensing capabilities that entail the passive or active triggering of fluorescent molecules or quantum dots. In the former, the sensing system signals & activates changes in or repair of the coating by sending data to an external detector, in the latter, the sensing system itself would be responsible for outputting the response signal.

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II. TRENDS IN AUTOMOTIVE COATING PROCESSES

The current trends in automotive coating process are motivated by lowering manufacturing costs, delivering customer satisfaction via aesthetic features and corrosion protection, and mitigating environmental concerns. A tremendous amount of consideration has been put into current automotive coating systems, and they have a level of sophistication that satisfies most customers around the world. Compared to 30 years ago, the problem of corrosion is almost alleviated, and the durability & appearance of the topcoats have become acceptable for the lifetime of a car. In fact, with the worldwide emergence of two-layer topcoats, the color, gloss, & chip resistance of automobile coating remain in relatively excellent condition during the first 7-10 years of an automoblie’s use. Aesthetic features are also trending with automotive fashions. Hence, a closer look at recent trends in automotive coatings is presented in the following:

1. POWDER COATING

Fig.1. Powder Coating

One solution to the emission of VOCs has been the replacements of liquid coatings with coatings in the form of dry, particulate solids, commonly called ‘powder coatings’. Their compositions contain very low concentrations of volatile solvents, on the order of 2% substanstially less than any other paint system. Currently, the automotive industry uses powder coating on wheels, bumpers, hubcaps, dorr handles, decorative trim & accent parts, truck beds, radiators, & numerous engine parts. A clear powder topcoat has been developed; BMW & Volvo are using it on their new model cars, & GM, Ford, & Chrysler have formed a consortium to test it on their production lines.

III. MODERN AUTOMOTIVE COATING PROCESSES

Modern automotive coating methods consists of five main steps. They include the following:

1) PRETREATMENT

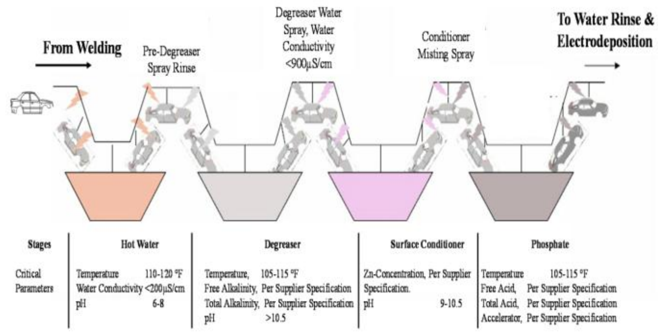

Fig.2. Pretreatment sequences for the body-in-white

The first sequence in preparing the BIW for subsequent coating is pretreatment sees Fig.2. Preatrament removes & clean excess metal & forms an appropriate surface structure enabling bonding of a corrosion protection layer. It consists of cleaning the body surface to remove remaining oils from the staming process & welding residues through three primary liquid dip processes of degreasing, conditioning, & phosphating.

Pretreament helps the primer to bond onto the metal. A phosphate treatment applies an inert layer of metal phosphate, providing resistance to corrosion spread. The degreasing solution is composed of alkaline salts & surfactants & can include caustic soda, sodium carbonate. The surfactants are types of detergents for emulsifying oils & lubricants on the BIW. In surface conditioner which creates nucleation sites for phosphate crystal growth. It increases the number of crystallization nuclei on the metal surface that enchance bonding mechanism for the subsequent phosphate sequence. Finally, the liquid dip phosphate ions, nitrate ions, zinc & hydrogen ions. The free acid etches the steel surface, causing hydrogen to be released while metal phosphate ions are precipitated onto the surface in a crystalline form.

2) ELETRODEPOSITION

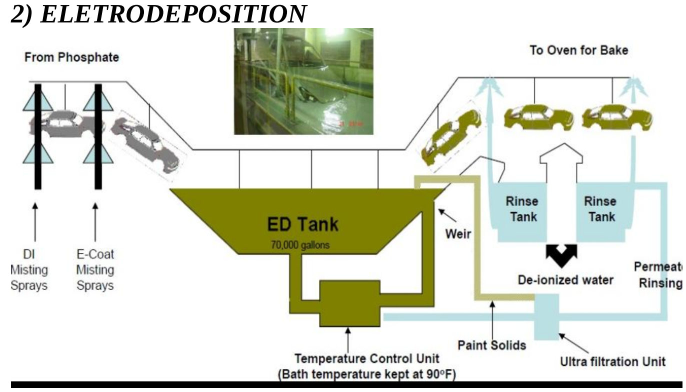

Fig.3. Electrodepostion coating process

E-coating involves dipping automobile bodies into the coating solution & passing an electric current through the body & the liquid ED paint solution. Because of the charged

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nature of this coating process, the ED paint penetrates into places a spray would not reach.

During operation, a mixture of resin, binder, & a paste containing the pigments is fed into the ED tank. The automobile body is lowered into the tank, & an electric current applied; the solution in the tank consists of 80-90% deionised water & 10-20% paint solids.The resin is the backbone of the final paint film & provides corrosion protection, durability, & toughness. Pigments are used to provide color & gloss.

After E-coat, the automobile body enters a bake oven, in which heating & keeping at a temperature of 160_C for 10 min causes film curing to promote maximum performance properties. The oven temperature & heating time primarily enchance chip resistance & film adhesion to the body; corrosion protected is affected less by these conditions. Because surface roughness influences the smoothness & brilliance of the topcoat, some sanding of the surface is usually performed to remove or eliminate defects before the body enters the next application step.

A common challenge in the cureent E-coating process is that of water spots that contaminate coated surfaces. If water spots are present, they have removed ny sanding. Hence, it is necessary to use well-deionoised water & routinely monitor its conductivity. Alternstely, operators also add surfactants or ultrafiltrates to the water rinse zone to eliminate or manage water spots

3) RUST-PROOF MATERIALS: SEALER/PVC

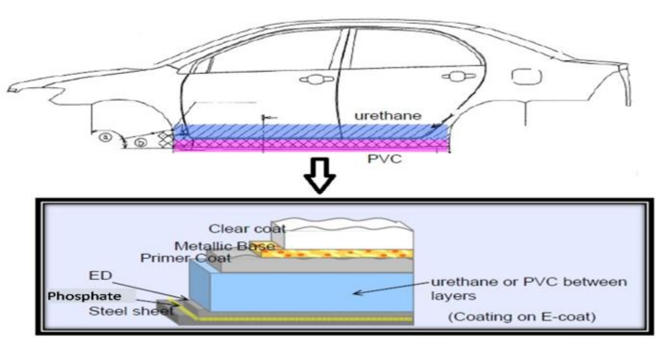

Fig.4. The Underbody Coating

The third step is underbody coating & seam sealing using PVC. Fig.4 displays the lower door sections & rocker panel locations where PVC or urethanes are applied as an anti-chipping protection, & shows the cross section of this layer with respect to the other coatings on the body parts.

During this third step, it is also typical to apply a soft tip primer coat that improves the chipping resistance . This layer is applied to the front edge of the hood , which is an area prone to chipping shock, using a high elastic resin that resides between the ED & primer coats. Also, during the third step, the radiator supports, wheel housing, & under rar areas of the body are coated with a relatively dull black pigment called a blackout coating.

4) PRIMER

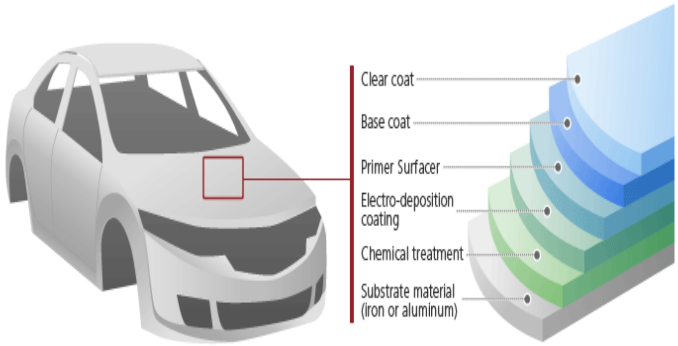

Fig.5. Primer Coating

The fourth coating step is the primer. It can be water-borne, solvent-borne, or a powder. The primer fills & smoothes minor imperfections & scratches that may be created during prior steps & by the intermediate sanding or grinding used to remove small imperfections. It also provides additional protection against corrosion & maximizes adhesion between it & the E-coat & basecoat; thereby, the primer incrases paint durability.

Primer coating operations in an automobile assembly plant are usually implemented in three stages: Interior coating, Exterior coating, & then cutting in an oven. Manual spray painting is used for the interior coating of the doors, engine compartment, & luggage or trunk space. Some of the areas are not sprayed with basecoat. It is important that are primer color matches the basecoat to be able to impart uniform coating appearances between interior & exterior coats.

5) TOPCOAT

The final step in the body coating process is to apply the topcoat, which consists of two layers the basecoat & clearcoat.

Basecoat: It contains the primary coloring pigments. As part of the topcoat, the basecoat is third layr added to the car after the primer & before the clearcoat. It imparts the automobiles color; roughly 40,000 base coat color are known today , & approximately 1000 new colors are added to this list each year. Three different types of basecoats are used for automobiles, including solvent-borne medium solids (MS), solvent-borne high solids (HS), & water-borne.

Clearcoat: The final coating on an automobile surface is the clearcoa; it provides durability, environmental etch, & scratch resistance to the overall coating. It protects against damage such as fading that is caused by UV rays from the sun & imparts a gloss & depth that otherwise are

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not as vivid. The clearcoat also makes repairs & maintenance easier. Environmental etch is an appearance issue associated with the formation of permanent water spots or non-removable marks from bird droppings, tree resin, or other chemicals after contact with an automobiles surface. The physical damage resulting from etchi=ng is associated with a localized loss of material & deformation or pitting of the clarcoat surface.

IV. AUTOMOTIVE COATING PERFORMANCE

The performance of an automotive coating can be accessed from different views, e.g., the durability of the exterior & interior paint finishes or the aesthetic features. However, limitations exist on the paint properties, process capabilities, & most importantly, the amount of money that can be spent to improve the finish. Consequently, each automotive company define its color & appearance standards, which are to meet or exceed the levels reached by competitors & customers expectations. For checking of coating performance we consider some features like:

a) Coating Quality: It can be judged on three main criteria: protection against harsh environment; durability; & appearance quality.

b) Color: Uniform & consistent color is essential to achieve the impression of a high-quality finish & avoid customer complaints. This issue is important not only at the time of purchase but also at the time of purchase but also throughout the lifetime of a vehicle. Factors that influence color tone are pigment orientation & concentration.

c) Corrosion Protection: Automobile coatings are subjected to a number of different environments & situations during their service life. Degradation of the coating depends on three main factors: coating formula, the intensities of the environments or situation, & their duration. Exposure to UV from the sun, heat, & humidity has a long term deleterious effect with different degrees of intensity depending on the climate & weather conditions.

V. CONCLUSION

Automotive coatings confront an almost limitless variety of environments & environmental assaults. Targeting customers, expectations, together with maximizing efficiencies & meeting environmental regulations with new processes, has brought automotive coating to a level not imagined 100 years ago. The appearance of the surface significantly affects a customer's perception of product quality. Additionally, customer expectations for the attributes given by the appearance of coating s continue to increase as manufactures compete to provide surfaces that offer enhanced surface characteristics.

The current paper gave a semi-comprehensive & up-to-date review of these new processes & coating technologies to be of value to industrial practitioners & researches. New developments in automotive coatings were chronicled & discusses, & then related to improvements in production technologies & paints. Modern automotive coating procedures were also discussed in details. Finally, the discussion covered recent trends in automotive coating processes & potential future developments.

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