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Investigation of Curing Temperature Influence on Gloss and Color Parameters of Pre-Painted Coils

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[1]MMK Metalurji Sanayi Ticaret ve Liman İşletmeciliği A.Ş., Dörtyol, Hatay

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Paint is a coating that is applied to any object to give color or to protect it. It is a chemical component that protects against physical and chemical effects by forming a film layer on the applied surface and provides decorative appearance.
Polyester paints, being topcoats that can be used both indoors and outdoors, are the most commonly used and most economical option in coil coating processes. They can be applied with wide brightness alternatives and color options. Brightness and color may vary depending on production parameters.
In this study, the effect of curing temperature on color and gloss of polyester topcoat RAL 3004, RAL 5010, RAL 9002 and RAL 9006 dyes were investigated. Reatec temperature-inductors (PMT tape) for curing control, Erichsen Paint Borer 518 MC for dry film thickness controls (with drill no 2 blade), BYK TRI-GlossMaster (60 °) for gloss control, X-Rite Ci7800 (for color control) CIELab, D65 / 10 °, d / 8 Geo.) devices were used.
As a result of this study, the increase in temperature shows decrease in gloss, while the increase in temperature shows different characteristics in different colors.

Keywords: Coil coating, gloss, color deviation, PPG, CIE

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1. Introduction

Paint is a coating that is applied to color to any object or for protection purposes. They are chemical components that create a film layer on the surface where it is applied, protecting against physical and chemical effects and providing a decorative appearance at the same time.
Dyes can be classified as follows considering the types of polymers according to binding content of the paint. [2]

- Polyester
- High Durable Polyester
- Wrinkle Polyester
- PUR-PA
- Polyurethane
- PVDF
- PVC(P)

The most common uses of polyester dyes in this study;

- Roof and side siding
- Sandwich panels
- White Goods,
- Automotive,
- Air conditioning,
- Heaters,

Figure 1: *The most common applications of polyester topcoat panels*

Strengths and weaknesses of polyester dyes;

Strengths	**Weaknesses**
Flexibility	External Resistance
Abrasion Resistance	Color Strength
Pencil Hardness	Brightness Resistance
Corrosion Resistance	
Moisture Resistance	
Impact Resistance	
Color and Brightness Options	
Lower Costs	
High Coverage Area	
Ease of Application	

2. Experimental Studies

2.1 Materials

All samples used in the study were produced by MMK Metallurgy Dörtyol galvanizing line. The properties of the samples were DX51D steel quality, 0.45 mm sheet thickness, coated with 100g / m² zinc and passivated, pre-treated with Cr^{6+}. After galvanizing, 5 µm chromate-free white primer [SP (CF)] was applied on the CCL line and the topcoat was made ready for application. Lined sheets are sized 15 x 20 cm in the laboratory and RAL 3004, RAL 5010, RAL 9002 and RAL 9006 topcoats are applied on them.

2.2 Devices and Equipment

Equipment	Model	Figure
Dry Film Thickness	Erichsen Paint Borer 518MC	
Gloss (°60)	BYK TRI-GlossMaster	
Color Deviation	X-Rite Ci7800 (CIELab, D65/10°, d/8 Geo.)	

3. Test and Assessment Method

Peak metal temperature in the production line affects color differently. Therefore, temperature differences have different effects on each color.

In many industrial companies, limited color difference is required as acceptance criteria in tolerance range dE. To make the CIE system easier to understand, the coordinates L, a, b, which are the mathematical conversion of tristimulus values (X, Y, Z) in the three-dimensional color space are used. dE concept; It is the mathematical formula of the distance between two points in a three-dimensional cartesian coordinate system. [1]

$$\Delta E = \left((\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2 \right)^{1/2}$$

ΔL (+) = light ; (-) = dark

Δa (+) = red ; (-) = green

Δb (+) = yellow ; (-) = blue

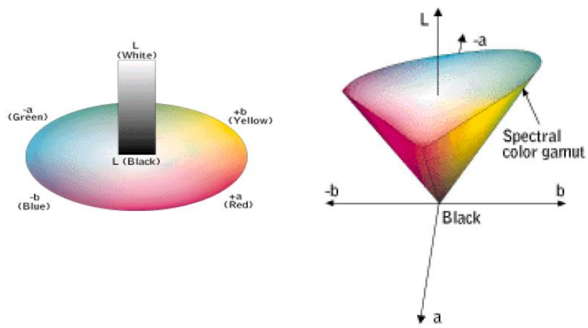
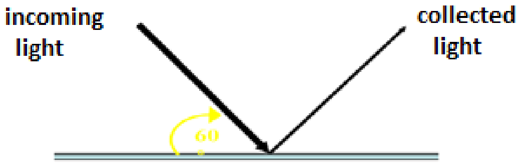


Figure 2: *CIE Color Space*

Brightness measurements were measured at the most common angle of 60°. Measurement at 20° and 85° angles is performed in some special applications. [1]



Since the guaranteed dry film thickness range of polyester topcoats is 20 ± 2 µm, paint thickness is aimed 20 µm. Wet paint curing temperature recommended by suppliers is 232-241°C, for metallic and pearl effect colors 241-249°C [6].
In order to understand the effect of curing degree; SP RAL 3004, SP RAL 5010, SP RAL 9002 and SP RAL 9006 paints with 20µ dry film thickness were applied on the panels prepared by applying 5 µ primer in CCL line and cured at different temperatures between 204-260 ° C.
Dry film thickness of the samples prepared by curing in the oven after wet paint application was carried out in accordance with ISO 2808 standard 6B method [3], brightness measurements according to EN 13523-2 standard [4], and color measurements according to EN 13523-3 standard [5].

3.1 Effects of Peak Metal Temperature on Color;

As standard 20 µm paint thickness were cured at temperatures (204-260 ° C). Color deviation were measured using the master values stored in the measurement device.

3.2 Effects of Peak Metal Temperature on Gloss;

As standard 20 µm paint thickness were cured at different temperatures (204-260 ° C) and brightness controls were performed.

4. Results and discussion

4.1 Effects of Peak Metal Temperature on Color;

a) RAL 3004;

RAL 3004					
PMT °C	DFT (µm)	dL	da	db	dE
216	20	0,08	-0,66	-0,18	0,69
224	20	0,04	-0,63	-0,17	0,65
232	20	0,42	0,28	0,24	0,56
243	20	0,18	-0,84	0,01	0,86
249	20	0,71	-0,85	0,15	0,88
254	20	0,24	-0,96	0,15	1,00
260	20	0,44	-1,17	0,37	1,30

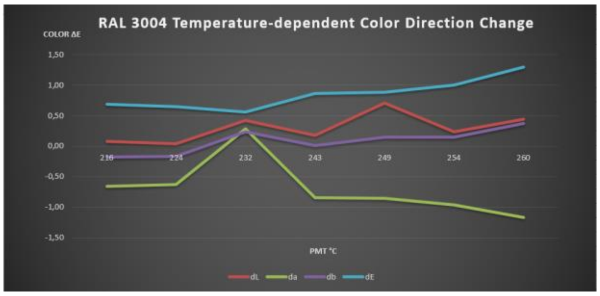


Figure 3: *RAL 3004 Temperature dependent Color Direction Change*

As can be seen in Figure 3, the increase in temperature and increase in da negative direction caused dE value to increase.

b) RAL 5010;

RAL 5010					
PMT °C	DFT (µm)	dL	da	db	dE
204	20	-0,11	-0,08	0,09	0,17
209	20	-0,08	-0,04	0,20	0,22
216	20	-0,07	-0,06	0,22	0,24
224	20	-0,08	-0,05	0,32	0,34
232	20	0,00	-0,06	0,43	0,43
243	20	0,01	-0,14	0,60	0,62
249	20	-0,02	-0,20	0,75	0,77
254	20	-0,03	-0,23	0,84	0,88

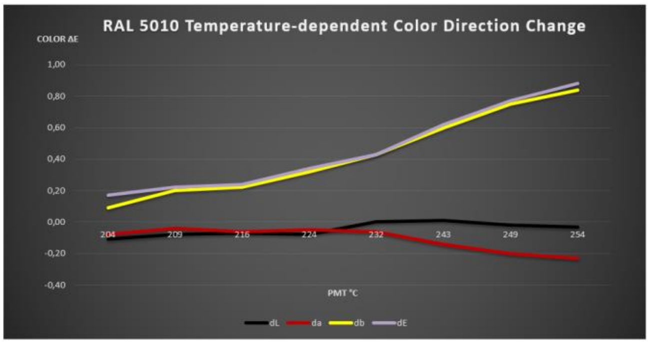


Figure 4: *RAL 5010 Temperature dependent Color Direction Change*

As shown in Figure 4, with the increase in temperature, no change in dL and da direction is observed. The increase in the db direction in the positive direction, that is, the yellow color, led to an increase in the dE value.

c) RAL 9002;

RAL 9002					
PMT °C	DFT (µm)	dL	da	db	dE
204	20	0,11	0,02	-0,08	0,14
209	20	0,10	0,02	-0,04	0,11
216	20	0,08	0,02	-0,07	0,11
224	20	0,02	-0,01	-0,12	0,12
232	20	0,00	-0,01	-0,12	0,12
243	20	0,00	-0,04	-0,04	0,06
249	20	0,02	-0,03	0,02	0,04
254	20	0,03	-0,02	0,03	0,05
260	20	0,02	-0,05	0,13	0,14

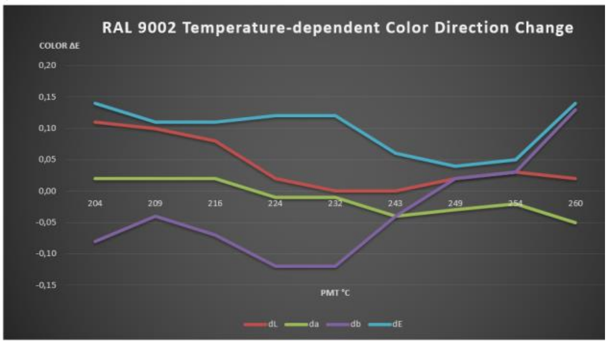


Figure 5: *RAL 9002 Temperature dependent Color Direction Change*

As shown in Figure 5, the increase in temperature did not show much effect on the dE value.

d) RAL 9006;

RAL 9006					
PMT °C	DFT (µm)	dL	da	db	dE
204	20	-1,78	-0,09	-0,32	1,81
209	20	-1,68	-0,08	-0,34	1,72
216	20	-1,57	-0,09	-0,33	1,61
224	20	-1,46	-0,09	-0,33	1,50
232	20	-1,40	-0,09	-0,31	1,43
243	20	-1,31	-0,10	-0,34	0,72
249	20	-0,75	-0,09	-0,33	0,83
254	20	-0,88	-0,10	-0,32	0,94
260	20	-0,97	-0,10	-0,27	1,01

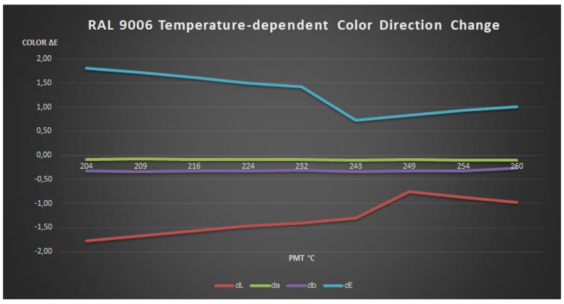


Figure 6: *RAL 9006 Temperature dependent Color Direction Change*

As shown in Figure 6, with the increase in temperature, while the value of da and db remained stable, the increase in dL positive direction leds to a decrease in the value of dE.

As a result, it can be said that there is no change for RAL 9002 with the increase of temperature, the color value of RAL 3004 and RAL 5010 dyes increases, whereas the color value of RAL 9006 dyes decreases.

4.2 Effects of Peak Metal Temperature on Gloss;

a) RAL 3004;

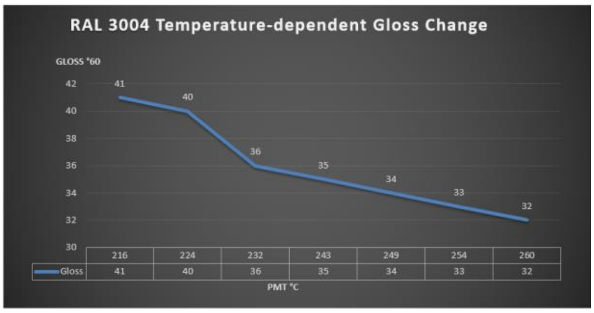


Figure 7: *RAL 3004 Temperature dependent gloss change*

As shown in Figure 7, with the increase in temperature, the brightness decrease after 224 ° C. The highest decrease of gloss is between 224-232 °C as 4 unit. There is a 9 unit gloss decreases in brightness between 216-260 ° C.

b) RAL 5010;

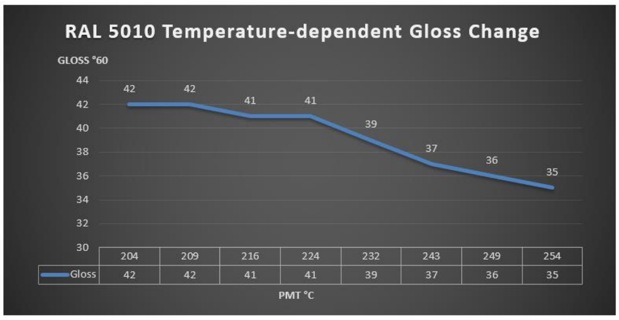


Figure 8: *RAL 5010 Temperature dependent gloss change*

As shown in Figure 8, with the increase in temperature, a decrease of 1-2 unit gloss was observed in each temperature range. Between 204-254 ° C there were 7 unit gloss drops in total.

c) RAL 9002;

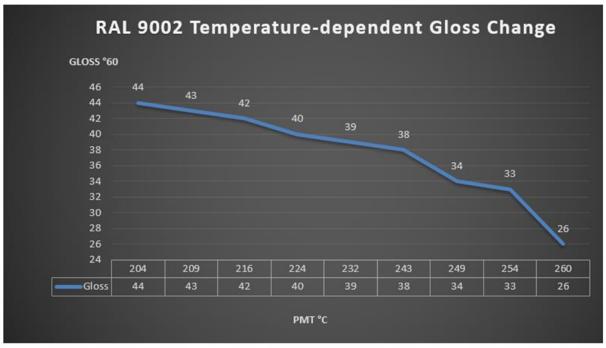


Figure 9: *RAL 9002 Temperature dependent gloss change*

Figure 9 shows a drop in gloss of 1-2 unit up to 243 ° C, there were 4 unit gloss drops between 243-249 ° C and 7 unit gloss drops between 254-260 ° C between 204-260 ° C a total of 18 glossiness decrease was observed.

d) RAL 9006;

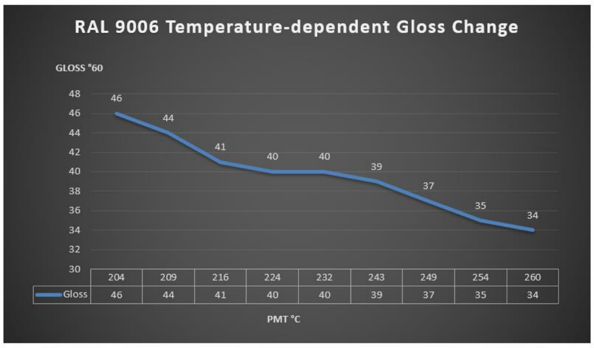


Figure 10: *RAL 9006 Temperature dependent gloss change*

As seen in Figure 10, with the increase in temperature, there was a decrease of 1-2 gloss between the temperatures. A total of 12 gloss declines were observed between 204-260 ° C.

References

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[2] MMK Metallurgy, Flat Product Catalog,2019

[3] ISO 2808 Paints and varnishes-Determination of Film Thickness (2007)

[4] TS EN 13523-2 Coil Coated Metals – Test Methots – Part 2: Gloss (February 2015)

[5] TS EN 13523-3 Coil Coated Metals – Test Methots – Part 3: Colour Difference – Instrumental Comparison (February 2015)

[6] AkzoNobel Coil Coatings, Technical Datasheet For Polyester Topcoat