

An Observation on Natural Weathering Effect on Colour and Gloss Properties of PPG Coils Based on Dörtyol/Hatay/Turkey Region Compared With Florida

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Abstract- Pre-painted galvanized (PPG) steel coils, comparing to galvanized coils, have better corrosion resistance and fascinating decorative properties with their color alternatives and glossy appearance. Color of PPG coils, during service period, by the effect of environmental conditions, fades and their surface lose their glossy appearance. This study investigated the color and gloss stability of PPG steel sheet samples, painted with 14 different colors and 3 different paint type. 23 parallel samples were exposed to natural environmental conditions during 2 years at two different locations, Florida/USA and Dörtyol/Hatay/Turkey. For natural tests, environmental meteorological parameters such as temperature, humidity, rain and various weather conditions are recorded monthly. This study shows the effect of natural environment of Dörtyol/Hatay/Turkey location and the regions similar meteorological conditions like Dörtyol/Hatay/Turkey on color and gloss of PPG coils.

Keywords: Natural Weathering, Gloss, Color, Pre-painted Galvanize, PPG, Dörtyol, Hatay, Turkey, Florida

I. INTRODUCTION

Pre-painted galvanized steel sheet (PPG) is a hot dip zinc coated steel, painted before forming, also known as pre-painted galvanized iron, pre-coated steel, coil coated steel, colour coated steel etc. Pre-painted steel sheet offers users a unique combination of advantages: the strength of steel, the corrosion resistance of coating and the beauty and additional corrosion protection of paint. Along with that flexibility of the coil coating process makes it possible to offer a wide range of finished surfaces (smooth, wrinkled, textured, orange peel effect etc.), which can be obtained in various levels of colours (saturated, metallic) and shining (matt, glossy).

In terms of lifespan performance, the demands on PPGs are much the same as on any other metal coating, to look good and to continue for the life of the product, while protecting the metal substrate. All of these properties are available in PPGs, but of course, improved performance will come at a cost, so it is important to specify a product which meets the requirements which are important in a given application without over-specifying an expensive product [1]. However, to achieve

desired lifespan it should be known environmental conditions which Pre-painted galvanized steel sheet product will be exposed in the service.

There are some test methods, used both by PPG producers and paint manufacturers around the world where surface properties are determined to be resistant to environmental conditions. These test methods are separated as natural and laboratory weathering. For natural weathering there are locations all around the world which are accepted as standard location because of their extreme weather conditions.[2] The extremely sunny, humid, and warm climate has been proven especially useful for certain types of testing including: Colour change, fading, and gloss loss, mechanical strength loss and physical deterioration, accelerated corrosion testing [3]. Manufacturers also take into account secondary effects (gases, pollution, acid rain, and blowing dust) and different climatic conditions (as a result different latitude, weather patterns, topographical and geographical features) because they do rather unique environments such as North America, Europe, India, Asia, Australia.

In Brazil, there is a different study about colour changes and gloss factor which shows the importance of testing the materials at many different sites, because each location has its particular set of influencing factors. The three natural weathering sites were geographically near but they presented rural, marine and urban atmospheres, which resulted in great differences in the exposure results [4]. Another study reveals the performance and durability of 11 industrial coating systems for two and a half years at five weathering sites in the industrial belt of Shuaiba Area, Kuwait in the Arabian Gulf. Experience has shown that under conditions like those in Kuwaiti industrial areas, degradation of coatings has tended to be faster than in the Western countries for which most of these coating systems were developed [5].

Because of different effect of locations on PPG performance, a study was done to define performance of PPG products of MMK Metalurji in the region where it locates. To have a comparison, Florida was chosen as benchmark location, because Florida is the internationally recognized benchmark location for outdoor exposure testing and has more specimens

on test than any other outdoor weathering facility in the world. (Site latitude 25° 27' North and longitude 80° 20' west).

As a result of study, performance of PPG products was observed in the region Dörtyol/Hatay/Turkey where performance of PPG products in Florida/USA is reference.

II. EXPERIMENTAL STUDIES

K. Materials

The samples which were used in this study had been produced by MMK Metalurji in hot deep galvanized line. Specifications of samples are given respectively, thickness range between 0.40 - 0.70 mm, coated with 100g/m² zinc and passivated, pre-treated with Cr⁶⁺, under coated with 5µm yellow undercoating (consisting of chromate) [SP(CR)], coated with 20 µm top coating paint. 3 different top coating paints with different RAL codes were used, these are polyester (SP), polyvinylidene fluoride (PVDF) and wrinkle polyester (SP-WR). The specimens used in the study were prepared by dimensioning them in the size of 15 * 20 cm from the same coil.

L. Devices and Equipment

Sizing of the samples made with Kanca brand 3BR4 300 model hand scissors.

The paint coating thicknesses of the sheets used in the work were measured with Erichsen Paint Borer 518S destructive thickness gauge and the gloss measurements at 60 ° with BYK TRI-GlossMaster device as shown Fig.1 and Fig 2.

Colour measurements of the painted sheets were made by X-Rite Color i7 colour spectrophotometer. The equipment is shown in Fig 3.



Fig.2 BYK TRI-GlossMaster



Fig.3 X-Rite Color i7 Colour Spectrophotometer



Fig.1 Erichsen Paint Borer 518S

M. Test and Assessment Method

For natural weathering test, the upper and lower parts of the samples were insulated with a waterproof tape. All the colour and brightness measurements were applied on those insulated panels. After that, samples were placed southwestwardly on a stand with 45° angle in the factory site of MMK Metalurji in Dörtyol/Hatay/Turkey. Fig.5

The stand is painted with a special paint type for painting ships to eliminate the effect of stand's corrosion on samples.

The colour and brightness values of painted panels were measured at South Florida and MMK Metalurji Dörtyol locations every 3 month periods. Before colour and gloss measurements were taken, the samples were washed with warm water (with detergent) and soft sponge without scratching the surfaces and then rinsed with pure water.

The samples were dried at room temperature and then measurements were taken. After the measurements were taken, the waterproof tapes of the samples were renewed and the stand was replaced for further testing.

Colour measurements are made in accordance with EN 13523-3 [6] standard with X-Rite Color i7 colour measuring device.

The gloss measurements were made at 60° with the BYK TRI-glossMaster device according to EN 13523-2 [7]

1. South Florida

Florida is located in Miami, the only tropical region of the United States, located on the southern of Florida with 25 ° 27' northern latitudes and 80° 20' east longitude. All season of the year in South Florida, temperatures are high. The tropical monsoon climate is dominant in the region, so the summer season is hot and humid, and the winter season is warm and dry. The average temperature in summer from 28 to 30 °C, while temperatures vary from 16 to 20 °C in winter. The rainy season is between June and October. Also, hurricanes happen in this period from time to time. Moisture increases with summer. Fig 4.



Fig.4 MMK Metalurji samples at natural weathering test area in Florida

Florida is an internationally recognized benchmark location for natural weathering test. Florida tropical weathering test is not only realistic test, but also accelerated test. Because in one year, insolation of Florida is equivalent to several years of anywhere insolation. The weather condition of Florida site is high intensity sunshine, annual high UV and high temperatures throughout the year, heavy rainfall and very high humidity.

2. MMK Metalurji Dörtyol/ Hatay/ Turkey

MMK Metalurji is located in Dörtyol at 36° 49' northern latitudes and 36° 13' east longitude, the southernmost in Turkey. Natural weathering stand location is 1 km away from sea and 38 m high from sea level in MMK Metalurji Dörtyol site.

Weather condition is typical Mediterranean climate, the summers are hot and dry, and the winters are warm and rainy.

There is snowfall for a few days. Annual range of temperature is between -6 °C and + 43 °C. The annual rainfall ranges from 562.2-1216.3 mm. The maximum rainfall falls in the winter, the lowest rainfall is seen in the summer. Fig 5



Fig.5 MMK Metalurji samples at natural weathering test area in Dörtyol/Hatay/Turkey

III. RESULTS

The PPG samples were exposed to natural environment for 24 months at South Florida and Dörtyol locations. The meteorological conditions data were recorded during this period and yearly averages were calculated.

Yearly temperature average values for South Florida and Dörtyol are 24.5 °C and 21.2 °C respectively. Monthly temperature distribution graphs are given at Fig 6.

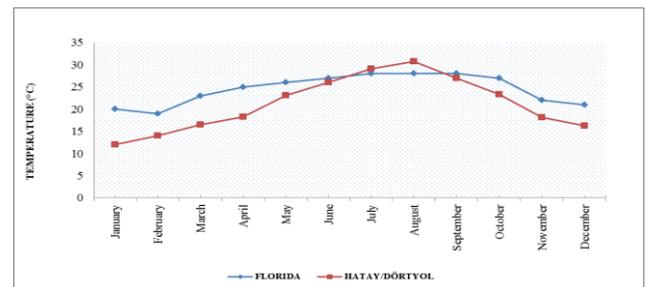


Fig 6. Yearly Temperature Distribution Graphs

Yearly rainfall average for South Florida and Dörtyol are 68.7 mm and 79.3 mm respectively. Monthly rainfall distribution graphs are given at Fig 7.

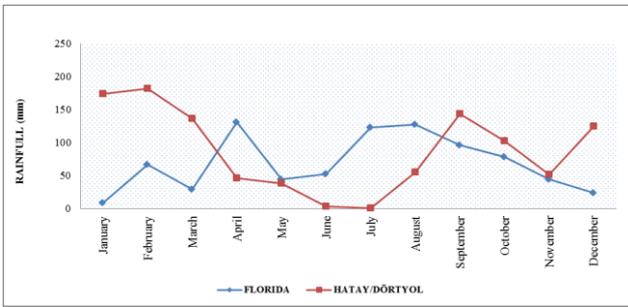


Fig 7. Yearly Rainfall Distribution Graphs

Yearly humidity average for South Florida and Dörtiyol are 78.0 % and 59.9 % respectively. Monthly rainfall distribution graphs are given at Fig 8

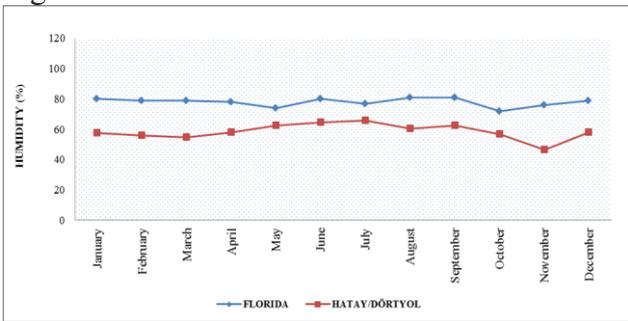


Fig 8. Yearly Humidity Distribution Graphs

Colour deviation and change on gloss value as protection% are recorded. The protection% values are calculated with the formula: 24th month gloss measurement value / initial gloss measurement value x 100. These data is given at Table 1

TABLE 1

COLOR DEVIATION AND GLOSS CHANGE % VALUES AFTER 24 MONTHS

COLOR	PAINT TYPE	GLOSS TYPE	MMK DÖRTIYOL (COLOR DEVIATION, ΔE)	MMK DÖRTIYOL GLOSS (% PROTECTION)	FLORIDA (COLOR DEVIATION, ΔE)	FLORIDA GLOSS (% PROTECTION)
MP 1014	SP	SEMIGLOSS	1,64	71,0	2,58	43,8
RAL 3004	SP	SEMIGLOSS	2,26	50,0	1,27	15,2
RAL 3004	SP	SEMIGLOSS	2,31	51,5	1,7	18,8
MP 3005	SP	SEMIGLOSS	0,82	61,3	0,99	32,3
RAL 3009	SP	SEMIGLOSS	0,65	27,0	1,31	8,3
RAL 3009	SP	SEMIGLOSS	0,81	29,4	0,84	8,8
MP 5005	SP	SEMIGLOSS	2,81	75,0	2,5	50,0
RAL 5010	SP	SEMIGLOSS	1,05	73,5	1,37	55,9
MP 6005	SP	SEMIGLOSS	1,4	66,7	1,58	38,9
RAL 6020	SP WR	MATT	0,76	100,0	0,65	75,0
MP 8017	SP	SEMIGLOSS	1,12	46,7	0,77	19,4
RAL 9002	SP	SEMIGLOSS	1,47	81,5	0,8	51,7
RAL 9002	SP	SEMIGLOSS	1,76	79,3	0,43	50,0
RAL 9002	SP	SEMIGLOSS	2,55	70,6	1,15	31,4
RAL 9002	SP	SEMIGLOSS	2,98	75,0	1,74	40,6
RAL 9002	SP	SEMIGLOSS	2,42	85,4	1,2	48,7
RAL 9002	PVDF	SEMIGLOSS	0,61	84,4	0,21	97,2
RAL 9002	PVDF	SEMIGLOSS	0,63	88,9	0,16	103,7
MP 9003	SP	SEMIGLOSS	5,48	44,8	3,49	28,6
RAL 9003	SP	HIGHGLOSS	2,77	87,9	1,4	82,6
RAL 9006	SP	SEMIGLOSS	0,62	88,2	0,54	63,9
RAL 9010	SP	SEMIGLOSS	4,73	56,5	2,68	34,8
RAL 9016	SP	SEMIGLOSS	2,09	76,3	1,57	52,6

According to the data given in Table 1, gloss protection % values in Dörtiyol is higher than that in South Florida except RAL 9002 PVDF type painted PPGs. The gloss protection% values according to the paint type and colours are given in Fig 9.

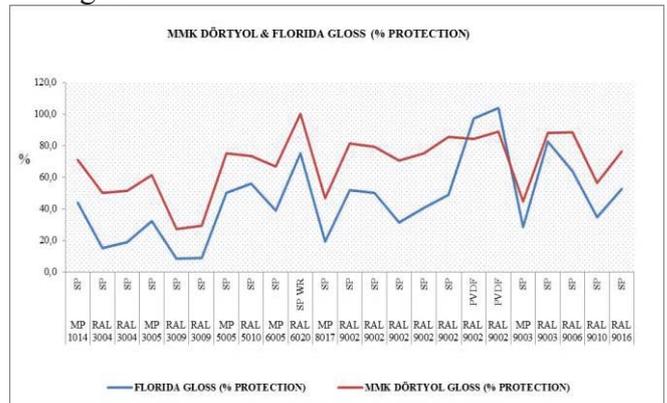


Fig 9. Gloss protection% Graphs according to the paint type and colours

For white colour tones (Ral 9002, 9003 and 9016) colour change quantity in Dörtiyol location is higher than that in South Florida and for the rest colours more or less the colour change quantities are the same. The colour change values according to the colours are given in Fig 10.

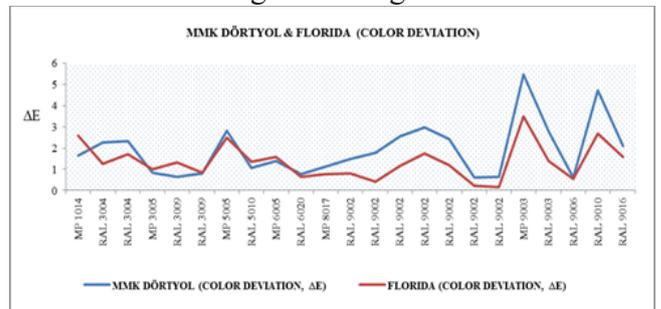


Fig 10. Colour Change Graph

IV. CONCLUSIONS

This study investigated that South Florida Location is more aggressive on reduction of gloss than Dörtyol Location for polyester type painted PPGs. Color deviation in Dörtyol location is higher than that in South Florida for white colour tones but for the rest colour tones there is not any significant difference on colour deviation.

V. ACKNOWLEDGMENT

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VI. REFERENCES

- [1] Choosing the Right Prepainted Metal Product, ECCA, Technical paper ,2010
- [2] Koleske J. V., Paint and Coating Testing Manual, 40th Edition, 2008
- [3] (2017) The Q-Lab Florida Outdoor Exposure Testing website. [Online]. Available: www.q-lab.com
- [4] Comparative Evaluation Between Accelerated and Outdoor Ageing of Brazilian Paints - Part one
- [5] Performance of Coating Systems in Industrial Atmosphere on the Arabian Gulf
- [6] EN 13523-3 Coil coated metals-Test Methods-Part 3: Color difference-Instrumental comparison
- [7] EN 13523-2 Coil coated metals - Test methods - Part 2: Gloss