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A Case study on blackening effect of Thermal Spray Aluminum Coating

Urvesh Vala

INOXCVA, Vadodara, India

urvesh.vala@inoxcva.com

Mihir Sheth

Sheth Corrosion & Coatings Pvt. Ltd, Vadodara, India

ABSTRACT

Thermal spray technique, where melted material is sprayed on the surface. Thermal coatings are getting more standard for particular applications such as onshore, offshore and critical atmospheric conditions also for corrosion under insulation (CUI). Thermal spray Aluminum (TSA) is very particular in CUI application, where service life of coating is expected over 25 years. General system followed nowadays is 250 to 350 microns of TSA on insulated surfaces and applied sealer and respective top coats on uninsulated surfaces over TSA coating. Considering all required testing such as adhesion test, bend test, porosity measurement, water spray and coating thickness test performed and accepted as per specification. In case of moisture and/or water entrapment or higher relative humidity environments, discoloration of TSA surface, black or grey shaded random patches is due to oxidation of aluminum and aluminum products on surface. This type of discoloration where all other physical testing are well within acceptable limits, where aesthetic is in the only question for acceptability which is not specified for this type of discoloration effects over TSA coating. In my present paper experiments are conducted to accelerate oxidation of TSA coated surface to conclude prospect of blackening effect.

Keywords: Thermal Spray; Aluminum Coating; Blackening effect; Corrosion resistant coating, TSA

INTRODUCTION

In this paper we have covered procedure for the application of metallic thermal spray coating of aluminum (TSA) and their alloys (85/15 Zn/Al) and composites for the corrosion protection of steel. Thermal Spray Aluminum (TSA) shall be applied by arc spraying, using a solid metal wire. In this we have covered required equipment, application procedures, and in-process quality control checkpoints and how they provide long term corrosion protection in services. Thermal spray coatings are a melted, or softened ceramic, metallic, or polymer materials are transported by a gas stream to a properly prepared substrate. These coatings are typically mechanically bonded to a grit blasted surface. Metals that feed into the thermal spray gun are the actual coatings. They are not a solvents or VOC's. The coatings are similar to the metals being sprayed, however there are some important differences. There are metal oxide stringers and porosity in the coatings. Metal particles in the coating create a layered effect within the coating structure. Due to the rapid cooling of the metal particles as they adhere to the substrates, thermal sprayed coatings have unique crystalline structures not normally found in wrought metals. Almost any material can be thermal sprayed onto almost any metal substrate.

Thermal spray, especially with soft metals sprayed with the combustion of wire equipment, is a relatively cold process as shown in Fig. 1. Substrate temperatures seldom reach more than 200 ^{0}F (95 ^{0}C).

Figure 1: Thermal spray coating by using aluminum metals

For atmospheric, buried, and marine environment corrosion protection, Aluminum (TSA), and Aluminum alloys have proven that they provide long term corrosion protection and outperform most all other methods. Anodic (TSA) metal coatings applied to steel cathodes (more noble than Aluminum), are referred to as cathodic or sacrificial protection coating systems. These thermal spray coatings provide corrosion protection by excluding the environment (or electrolyte) and acting as a barrier coating (like paints, polymers, and epoxies), but unlike typical barrier coatings they also provide sacrificial anodic protection. Costal, Industrial & Chemical areas where Salts and Chemical environments make rate of corrosion very high and life of structures can be increased by 3 times by reducing rate of corrosion.

EXPERIMENTAL PROCEDURE

Material used for application is aluminum in accordance with ISO 209, Grade 1100.

Surface preparation activities shall be applied to remove salt contamination of parts that have been stored in and exposed to the open air prior to blast cleaning. The surface made free of any contamination & excessive rust scale removed prior to blast cleaning. The surfaces rinsed with fresh and clean potable water, after detergents used with water chloride less than 25 PPM.

The abrasives used free from oil, grease, moisture, chloride contamination etc. and meet standard ISO 11124-2 requirements. Iron grit used as abrasives. A bottle test for evaluating oil contamination of surface preparation abrasives shall be performed by filling a small, clean bottle (approximately 100 ml to 200 ml) half full of abrasive particles. Fill the remainder of the bottle with distilled water. Cap and shake the bottle. Inspect the water for oil sheen or other contamination. The surface finish shall be SA 2.5 in accordance with ISO 8501-1. The dust level on the blast-cleaned surface at the time of coating, rating 1 in accordance with ISO 8502-3. The surface roughness measured by means of replica tape or by digital surface gauge, in accordance with ISO 8503-5 and between 75 µ to 110 µ. The compressed air used as blast equipment, which is free of water and oil, and same has been tested in accordance with ASTM D 4285.

Thermal spray equipment shall be set up, calibrated, and operated according to the instructions and technical manuals of the manufacturer or thermal spray applicator. The thermal spray equipment's spray parameter set up validated with a bend test. The spray equipment operated in accordance with the manufacturer's instructions and thermal sprayer's procedures in line with international codes and standard requirements.

Time between blasting of the steel surface and thermal spraying no greater than 4 hours. Dew point determination in accordance with ISO 8502-4 for TSA coating three times a day or starting of each shift per day.

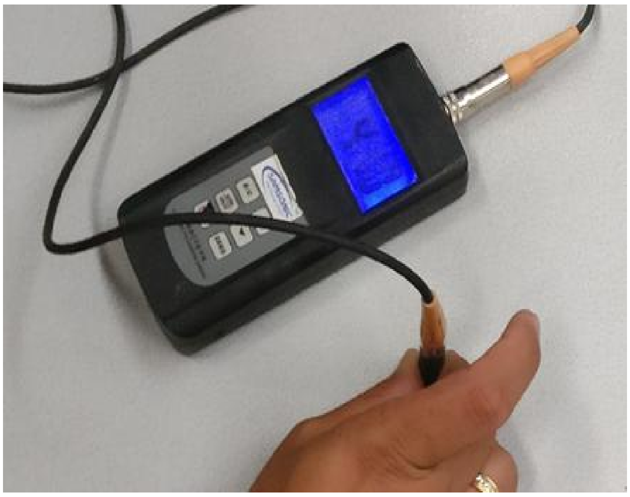
Thickness of the coating system shall be minimum of 250 microns and maximum not exceeding 500 microns, with normal range between 350 microns to 450 microns.

RESULTS

TSA Coating on Test Coupon #1 sprayed with tap water over the surface:

Discoloration of TSA surface under different concentration of moisture in open to atmosphere condition and covered in wrap (Packed) condition.

In Test Piece #1 – sprayed (sprinkled) with tap water. Covered half portion with clear plastic packing wrap and half kept open.



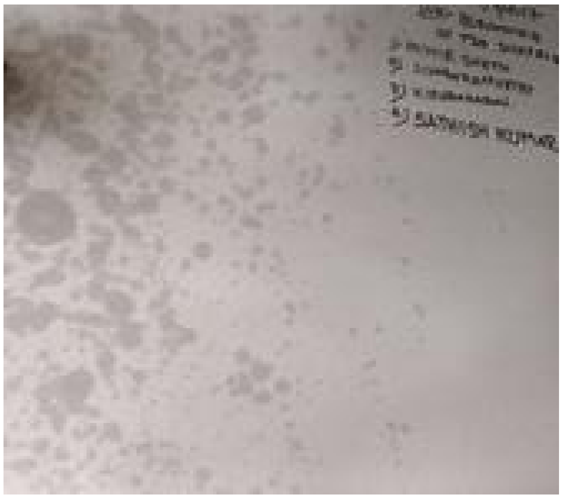


Figure 2: TSA coating thickness check test

Figure 3: Water sprayed on TSA Surface

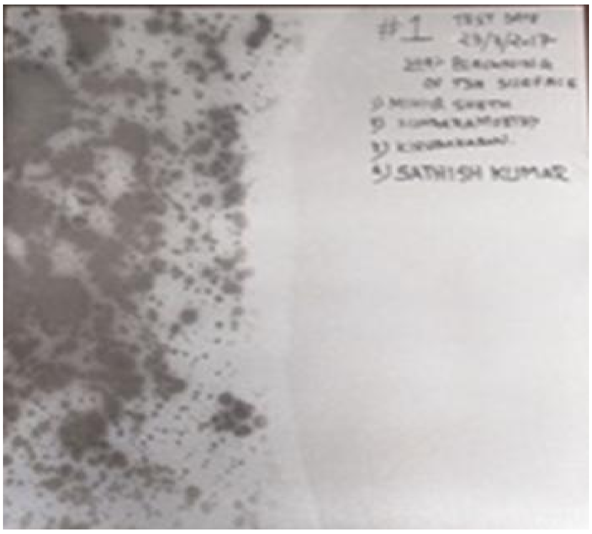


Figure 4: Half covered with plastic wrap

Figure 5: Coating condition after 24 hours

TSA Coating on Test Coupon #2 surface wetted completely with tap water:

Test Subject Discoloration of TSA surface under different concentration of moisture in open to atmosphere condition and covered in wrap (Packed) condition.

In Test Piece #2 – Surface wetted completely with tap water. Covered half portion with clear plastic packing wrap and half kept open.

Figure 6: Adhesion Test

Figure 7: Wetting surface with tap water

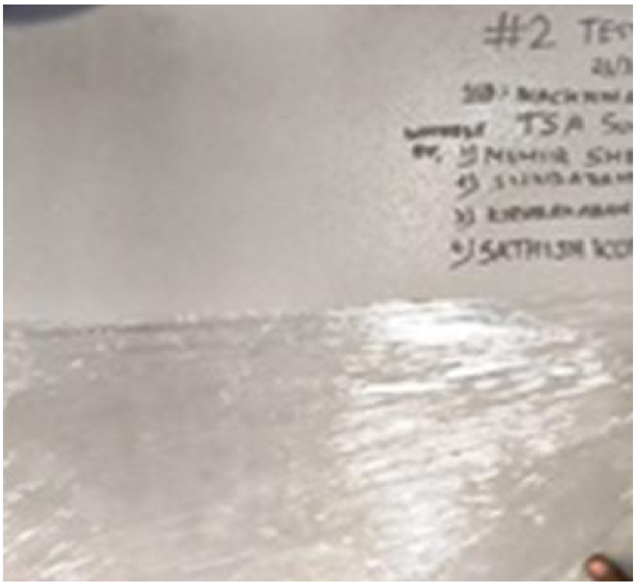


Figure 8: Wet surface covered in half portion

Figure 9: Coating condition after 24 hours

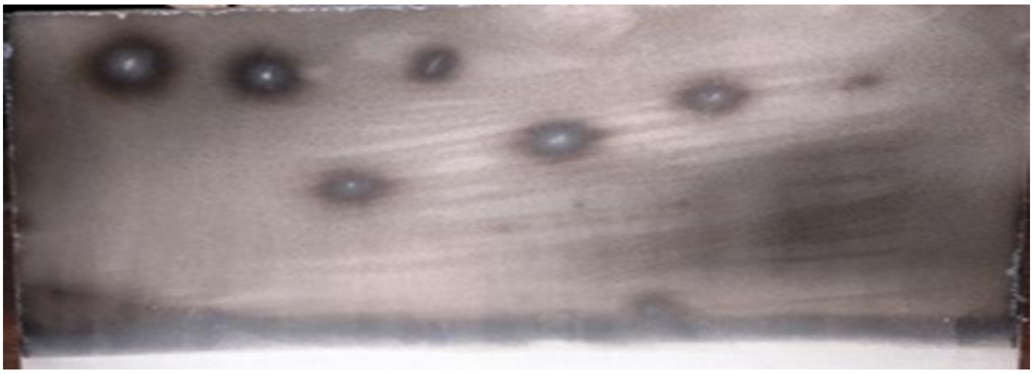


Figure 10: Coating condition of surface with localized punctured area

Figure 2 shows the TSA Coating thickness measurement by thickness gauge and Figure 6 shows the adhesion test performed on the TSA coated samples for study the quality of metallic bonding.

From above testing results of Test Coupon #1 and Test Coupon #2 and further analysis of TSA coating with respect to mechanical bonding of TSA coating we measure dry film thickness and performed bend test and adhesion test of TSA coated samples results. A detail visual examination of the TSA coated surfaces are carried out and following results are tabulated in Table 1 and Table 2.

Table 1: TSA Coating on Test Coupon #1 sprayed with tap water over the surface

Item Description	Dry Film Thickness (DFT) (µ)					Avg. DFT (µ)	Bend Test	Adhesion Test	Visual Inspection
ME-214-101-EJ01A	278	299	423	479	385	394.9	Accepted	Accepted	Accepted
	295	347	487	492	377				
	327	359	521	428	427				

Table 2: TSA Coating on Test Coupon #2 surface wetted completely with tap water

Item Description	Dry Film Thickness (DFT) (µ)					Avg. DFT (µ)	Bend Test	Adhesion Test	Visual Inspection
ME-214-101-EJ01A	267	342	332	430	387	365.4	Accepted	Accepted	Accepted
	289	339	373	451	358				
	295	327	419	399	473				

CONCLUSIONS

As per figure 5, it is to be consider that area where water was sprinkled and covered with plastic wrap, is having grey discoloration. Half portion which was kept open to atmosphere is having no signs of discoloration.

As per figure 10, completely wet surface covered with plastic wrap is having uniform discoloration. To be noted that punctured holes where air circulation was possible are easily identifiable with blackish clouds.

As per table 1 & table 2, required tests such as coating thickness, bend, adhesion and visuals are conducted to analyze integrity of coating after blackening effect. It is to be consider that except discoloration which is aesthetic aspect all other results are meeting code requirements. Most of the cases where TSA is specified are Corrosion under insulation (CUI) and the surface will be covered under insulation, in which aesthetic may not be an issue.

The TAS Coated samples with SEM and EDEX analysis in laboratory to verify the effect of tap water over TAS Coating for further study in the blackening effects are in progress.

REFERENCES

1. ISO 4624: Pull of test for adhesion.

2. ASTM D 4285: Standard Test Method of indicating Oil or water in compressed air.

3. ISO 209: Aluminum Chemical Composition.

4. ISO 2808: Measurement of coating thickness.

5. ISO 8501-1: Preparation of steel substrates before application of paints and related Products – Visual Assessment of surface cleanliness.

6. ISO 8502-3: Preparation of steel substrates before application of paints and related products – Tests for Assessment of surface cleanliness- part 3- Assessment of dust (Pressure –sensitive tape method)

7. ISO 8502-4: Preparation of steel substrates before application of paints and related products – Tests for Assessment of surface cleanliness- part 4- Guidance on the estimation of the probability of the condensation prior to paint Application.

8. ISO 8502-6 & ISO 8502-9: Preparation of steel substrates before application of paints and related products – Tests for Assessment of surface cleanliness- part 6 & 9 - Determination of water soluble salts by SCM method.

9. ISO 8503-5: Preparation of steel substrates before application of paints and related products – Surface roughness characteristics of blast cleaning steel substrates- part -5, Replica tape test method.

10. ISO 8504-2: Preparation of steel substrates before application of paints and related products – Surface preparation method- Part 2- Abrasive blast cleaning.

11. ISO 14918: Thermal Spraying – Approval testing of thermal sprayers.