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'Zinganising' – cold-dip galvanizing?

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Zinc coatings

For many decades now, metal finishing companies around the world have searched for the ideal solution for the corrosion protection of lightweight carbon steel through the use of zinc coatings.

These systems have included zinc plating, hot-dip galvanizing (HDG) and 'Sherardising', but over the years it was discovered that: (a) the plating process left a low-build zinc finish that would not tolerate long outdoor exposures; (b) HDG had limitations on metal thickness; (c) Sherardising was limited to the smaller, solid metal objects like fasteners that would not become damaged or distorted during the tumbling process or would succumb to the heat used during the coating process.

In this article, we take a very brief look at the different processes.

Electroplated zinc

With zinc electroplating, metal-finishing companies have had varying degrees of success, but with average zinc-coating thicknesses of around 12-15µm being the norm, the un-painted zinc finishes were restricted to the coating of items that would not be exposed to aggressive atmospheric conditions. To help lengthen the zinc's working life, many coaters finished off their plating process with the application of waxes or other passivation chemicals, and this caused havoc when trying to apply aesthetic finishing colours with either powder or wet paint finishes.

Metal-finishers globally have also had problems with zinc out-gassing through partially-cured powder-coats and unwanted reactions from the brighteners and organic additives in the zinc bath.

The typical surface finish is extremely smooth compared with HDG finishes, but at around only 17% of the of the finished zinc thickness of an HDG finish.

Hot-dip galvanizing

Looking at the other side of the galvanizing debate, the major stumbling-block that has arisen time and again is the minimum section thickness for the application of hot-dip galvanizing (HDG). Normally, the minimum thickness of any steel plate to be protected by HDG will be around 3mm. Below that thickness, the metal can distort quite badly and the whole process would be a non-starter.

Even when coating 3mm carbon steel plate with HDG, if an aesthetic finish is required it still means that the zinc has to be fettled to remove any "snotters" and "whiskers" prior to being treated with an acid-wash of some kind. It then needs to be coated with a suitable etch-primer before any aesthetic finish can be applied. The etching-action from the primer can provide two things – it helps the final finish paint coat bind with the metallic zinc substrate and it helps seal surface porosities.

The new-age vinyl paints designed to be applied directly onto HDG zinc can work well, but there have been occasions where it started flaking off after only a few weeks due to the passivation layer not being properly and completely removed from the zinc.

In these cases the paint had to be removed in its entirety and the zinc then properly cleaned off prior to the paint being re-applied.

'Sherardising'

This type of zinc coating is usually linked to the corrosion protection of fasteners, and as is the same with HDG, after degreasing the metal has to be either shot-blasted or pickled to ensure that the substrate is clean and properly prepared before attempting to coat it.

The zinc powder normally contains around 96% pure zinc dust with additions of lead, cadmium and things like zinc chloride (up to 2%). These mixtures normally require pre-heating at high temperatures of up to 800°C prior to being packed into a tumbling drum with sand and the metal items to be coated.

The Sherardising process will coat metallic fasteners with a zinc/zinc oxide layer but salt-spray testing has shown that the finish does not always give as many hours of protection as compared to some zinc epoxy paints. This is mainly due to the micro-cracking that takes place as the zinc coating experiences differential cooling rates during this cycle.

'Zinganising'

This is a matt-finish film-galvanizing system that has now become well established in 52 countries around the world. 'Zinganising' has many distinct advantages over the other systems, namely: (a) it is done at ambient temperatures; (b) there is no restriction on metal section; (c) it can be used on both carbon steels and on cast iron; (d) it can be over-coated directly with certain powders and wet paints without the need for etch primers; (e) it can be used on immersed steelwork and on exposed structures; (f) it is used successfully on fasteners for North Sea offshore use.

For 35 years the system has been used very successfully, but with one important stipulation.

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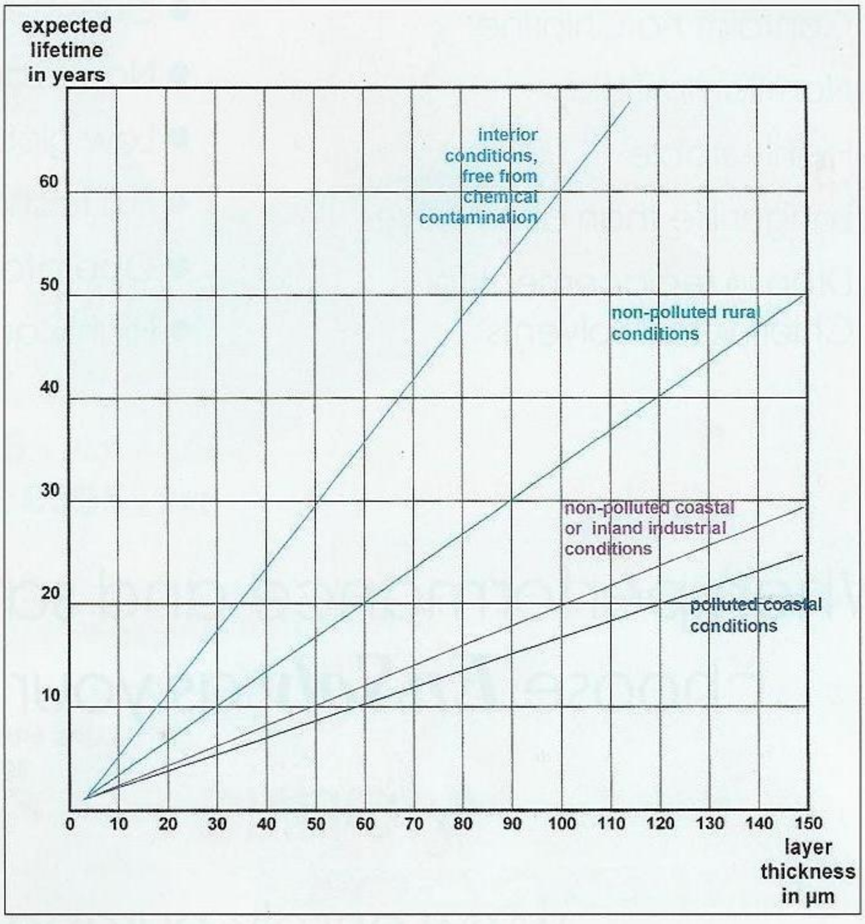

Lifetime expectancy graph for 'Zinga'.

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The metal has to be blast-cleaned to a cleanliness standard of SA2.5 (SSPC-SP10) and with a blast-profile average of Rz65μm (ISO 8301-1) and a roughness factor of Ra12.5 (8503-2).

The zinc thickness is approximately 65μm DFT from dipping (at 19 seconds Ford 4) and because the zinc dust is micronised, the surface finish is always glass-smooth and ready for a paint coating if one is required. Unlike a shiny zinc-plated finish, the matt grey finish of 'Zinga' allows a range of paints to be applied directly onto the zinc with no requirement for a primer.

A 'Zinganised' coating will lose a maximum of around 1-2μm DFT of zinc per annum from its applied thickness under normal atmospheric exposure, and around 3-4μm DFT (worst-case scenario) per annum in very exposed marine atmospheres.

As two-pack polyurethanes can be applied directly onto zinganised surfaces, the application of such a paint coating should give a working lifespan of around 20-25 years in exposed marine atmospheres. This is because Zinga has a "synergisation factor" of around 2.5, which means that the zinc and the paint coating are working in symbiosis.

Paint breakdown mechanism: Normally, a polyurethane paint would start breaking down from UV exposure after, say, 12-15 years. This would start off with the resin becoming porous (with the formation of micro-pores through the film) and with water-vapour transmission taking place. Vapour or condensates from rain and overnight dew would permeate the paint-film, reactivate any salts or salt-residues behind the paint film (or in many cases carry the salt through the paint-film in an ionic form, as nitrates come from dissolved atmospheric nitrogen and chlorides can come from road spray and wind-borne moisture etc) and the corrosion process begins.

The paint-film becomes undercut and the corrosion products that are continually forming behind the film will swell and push the paint off in the form of blistering and flaking.

Zinga in duplex: When paints like two-pack polyurethanes are applied over Zinga, they will start to degrade from UV exposure as normal after 12 or so years. The difference here is that once the moisture penetrates the paint-film and reaches the zinc layer, the zinc immediately reacts with this moisture and forms both carbonates and oxides, both of which are non-conductive and therefore cannot carry any form of ionic species through to the zinc. These salts block and effectively seal the paint-film against further ingress from water vapour and dissolved salts, which in turn lengthens the coating's working life.

Why? Quite simply, because no reactions are taking place behind the paint-film and hence no by-products can form that will weaken the bond between zinc and paint.

With this symbiotic relationship, the coating will break down repeatedly in layers from the exterior face, losing more resin thickness each time with the subsequent loss of more and more pigmentation as it gets washed away by rain and the elements. This results in the coating physically wearing away back to the zinc layer, which has not really had to do any real work up to this point. Only when the paint has worn away completely in certain areas will the zinc begin to 'work' in these areas.

Under immersion: The zinc will generate a voltage of around 1.04V (open circuit voltage) and once it has coupled with carbon-steel and is wet from dew or rain (or from working under immersion) the voltage will usually drop to around 0.85 -875mV (when tested against a silver/silver chloride half-cell).

Even under immersion conditions the zinc will continue to work satisfactorily, but in marine waters the sodium salts that are present (chlorides) will remove the zinc carbonates (hydroxycarbonates) from the surface and will cause the zinc to dissolve at an accelerated rate to protect the steel underneath. However, this zinc dissolution process will only last for a few weeks as another reaction has already started; namely molecular displacement. This is where each molecule of zinc that dissolves out of the film is replaced with, amongst others, a complex molecule of magnesium carbonate/chloride.

After approximately 12 months, the zinc layer becomes 'plated' with a hard white insoluble layer that actually passivates the zinc and completely slows down all reactions. This adds years to the life of the zinc coating.

New phosphate process

Steel constructions that had tight returns like lid rebates, C-channels and boxed-in sections (to act as stiffeners) were impossible to blast-clean and it was just not possible to apply Zinga into these sections or onto the interior surfaces.

A new system is now available whereby the metal is treated with a unique phosphating process that deposits 1200g/m^2 as opposed to the old range of 12g-20g/m^2.

This is quite impressive when one considers that in-line galvanizing only deposits around 100g/m^2 of zinc.

This new phosphate treatment is so coarse that it both looks and feels like a blast-cleaned surface, but with the added advantage that it also converts the surfaces of all the hidden and closed-in areas as well.

This treatment is longer than the usual phosphate system, having an immersion-time of around 25-30 minutes, but the extra time is well worth the finish that is achieved.

There are no short-cuts to this period of immersion, as this is the minimum time to achieve the desired crystal size on the surface.

To maintain the solution strength in the tank, test-coupons of a known weight (made from carbon or Cr MO steel) are used every three months to check weights, and the weights across the panels should be in the range of 10,000 -18,500g/m^2 average.

Parts to be dipped that have a heavy rust deposit on the surface or have a thick scale deposit from the steel manufacturing process should be blast-cleaned prior to going into the alkali degreasing tank.

The articles being coated would go through the usual seven-stage phosphating process up to the point where they would normally be ready to be coated with oil. Here the system changes.

Dipping in Zinga

At this point, however, the phosphated items would not be coated with oil but instead would be immersed in a tank of Zinga, and the liquid zinc would have a viscosity of around 19 seconds (DIN Ford 4 Cup) and the dipping would be at ambient temperatures.

A single dip, taking under three seconds for immersion, would deposit in the range of approximately 50-65μm DFT of zinc on the phosphated surface.

If the zinc is thinned down to say 16 seconds then the DFT would be around 45-50μm.

There are restrictions on surface areas and these are normally limited to around a maximum of 6 inches, as the zinc may start 'setting up' and on wider surfaces a 'curtain' may form where the zinc stops travelling due to solvent evaporation.

If the withdrawal speed has been set up correctly on the overhead conveyor, then no zinc should be seen dripping off the bottom edges of the dipped item. Where possible, the article being coated should be suspended in such a manner that there is a single 'drip-off' point. With a fine piano wire stretched across the end of the tank and running at 12 volts DC and with a negative charge on the tank and a positive charge on the conveyor, the single drip of zinc should "jump" back into the dip-tank.

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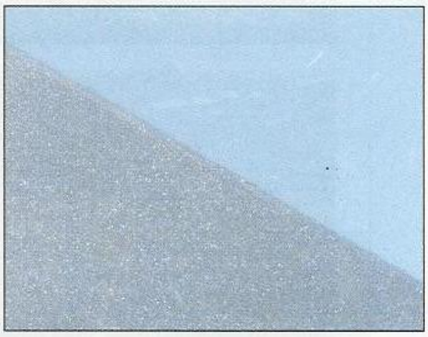
Zinga over the old phosphate system using weights of 20g/m2 and with pull-off values of 4MPa.



The new phosphating process with weights of1200g/m2. Initial testing has shown pull-off values at around 7 MPa. The zinc is above right in the photograph and the rough phosphate is low left.

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Tow-bars cold-galvanised with 'Zinga'. These units would normally be finished with a wet coating such as a 2K polyurethane.

The stainless-steel drip-tray adjacent to the tank will collect any rogue zinc droplets, and after a week or two they are scraped back into the dip-tank where they re-liquidise. This means that the zinc usage is almost 100%, with almost nothing being wasted or being drawn through extractor fans to contaminate the atmosphere. On large-volume projects, Zinga-coated items could be run through a drying tunnel at 40°C where the zinc coating would normally be hard within 5 minutes.

With powder applications, the coated items are put through the baking oven at 200°C for between 10-20 minutes (depending on the powder-type) to de-gas the zinc prior to application of the powder. Once the items have left the oven and have cooled down to approximately 50°C, the powder can be applied and the items put back into the oven for their normal baking schedule.

If a high-gloss finish is required and there are out-gassing problems with the zinc, to avoid using non-gassing powders (which produce a duller finish) the zinc layer can be coated with a PVB (polyvinylbutyral) primer at a low layer thickness (in the range of 20-40µm DFT) and this will seal the zinc porosities and prevent gassing.

This type of primer is very inexpensive (covering 50m^2/5 litre tin) and does not hold up the coating process, because it can be applied over the Zinga layer after only 10 minutes drying time and can be baked simultaneously with the zinc.

Dipped 'Zinganised' steelwork for the MoD. Note: The zinc has taken on a mottled appearance due to its early exposure to rain soon after being coated. This is very good for the coating's morphology.

For more information on the 'Zinga' system, phone MG Duff on 01243 533336. www.Zinga-uk.com

For further details of the new phosphate system, phone Steve Moore at East Midland Coatings on 01455 619176. www.eastmidlandcoating.co.uk

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