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APPLICATION METHODS AND SELECTED PROPERTIES OF ZINC FLAKE COATINGS

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The lamellar technology, also known as flake galvanising, is gaining an increasing share of the zinc coating market. This share mainly covers the area of fasteners, such as nuts, screws, bolts, buckles and springs. The unquestionable advantages of flake coatings include, among others, high corrosion resistance, total absence of chromium (VI) and hydrogenation of the parts, as well as good resistance to chemicals or UV resistance. This paper presents application methods and selected properties of zinc flake coatings.

Keywords: zinc, flake coatings, flake coating properties, flake coating technologies, salt chamber

INTRODUCTION

The European Union's End of Life Vehicle Directive implemented in 2000 (2000/53/EC) to ensure the recycling of scrapped combustion vehicles has reduced the use of toxic heavy metals such as chromium(VI), mercury, cadmium and lead in the manufacture of combustion vehicles. The Directive also prohibits the use of chromium(VI) in the automotive, electro-mechanical, and electronic industries [1].

The ban on the use of chromium(VI) has introduced significant changes in the performance of protective coatings. Chromium(VI) is currently being replaced by chromium(III), which is considered to be non-toxic, but in some cases it is not as effective as its predecessor.

All coatings, both metallic and non-metallic, applied to base materials form a protective layer to prevent corrosion of the material beneath it. Non-metallic coatings (paints, varnishes, oils, greases, etc.) are electrically non-conductive and when evenly applied they protect the workpiece until the coating is damaged. Metallic coatings, in turn, are conductive and have a more active function in preventing and controlling corrosion [2].

In the case of workpieces coated with less precious metals such as Cd, Al, Zn, Zn-Al (zinc flakes), the less precious metals protect not only as a coating but also prevent corrosion of the base material despite the damage. This action is called "protector protection" as the coating corrodes first in the direction of the workpiece beneath it. This phenomenon occurs under normal atmospheric conditions, but at temperatures above 85°C there is no zinc protector protection on steel [2].

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The choice of the corrosion protection method depends primarily on the purpose of the component. However, at the moment an increasingly popular method of corrosion protection is the lamellar (flake) method.

FLAKE ZINC COATING

The lamellar technology uses zinc to protect steel. This process consists in immersion of steel elements in a solution of zinc or Zn-Al, as well as binding and hardening components. This paint-like liquid is deposited on the steel surface and the excess liquid is removed in the process of spinning. Then the steel parts are heated up at 120 - 300 °C. During the annealing process the solvent evaporates and the zinc layer hardens [3].

The lamellar coatings are made with topcoats that increase the corrosion resistance or allow to obtain a specific colour with the use of lubricants applied to the base layer. ISO 10683 [4] distinguishes 4 systems:

- base coat
- base coat and lubricant
- base coat and topcoat
- base coat and topcoat and lubricant.

Lamellar coatings containing lubricant integrated into or applied to the base coat provide a controlled coefficient of friction [5].

The lamellar technology has been used in the automotive, energy and aviation industries, as well as among suppliers in all areas of new technologies.

FLAKE ZINC SYSTEMS

In practice, there are several zinc flake coating systems, including Zintek, Geomet, Magni, and Delta. A diagram of the structure of the zinc flake coating is shown in Figure 1.

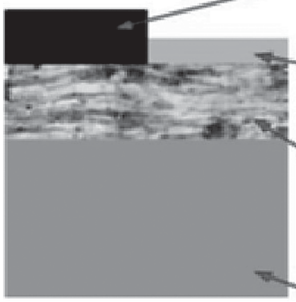

Figure 1 Structural diagram of zinc flake coating [6].

The following items are most often covered with zinc flakes [7]

- threaded fasteners, especially in strength class: 10,9 and 12,9.
- mouldings, springs, clamps,
- high tensile steel elements (especially above 1 000 N/mm^2) and hardened elements for which surface protection without the risk of hydrogen embrittlement is required.
- steel elements, sintered and cast.
- complex shaped parts with holes and cavities.
- complex elements, e.g. parts of locks or connectors, elements of rubber hoses.

Flake technology protects elements in difficult corrosive conditions.

The Zintek technology has been used to apply flake zinc to fasteners in the automotive, construction and household appliances industries.

The Zintek base coat is a lacquer containing zinc and aluminium 'flakes,' which reacts with the surface of steel parts to form a highly conductive and non-toxic zinc-aluminium coating after heating. The mechanism of corrosion protection is the same as in the case of galvanised zinc coating. The resulting coating does not contain heavy metals such as chrome, mercury, cadmium or lead. Due to the fact that the coating is applied using the currentless method, no hydrogenation of the substrate takes place, and thus no hydrogen embrittlement occurs. The base coat created in the Zintek technology can have both silver and black colouring [8].

Zintek base coatings are often finished with an organic or inorganic sealing layer that ensures high corrosion resistance and (owing to the introduction of an appropriate additive) coatings with adjustable torque force, which is necessary for screwing. Organic seals can also be coloured in various RAL colours. The advantages of the Zintek technology coatings are high corrosion resistance (up to 1 000 hours in a salt chamber for red corrosion), total absence of Cr (VI), high temperature and chemical resistance [8].

Geomet coatings, on the other hand, are made on the basis of water containing zinc from the form of flakes and are used to ensure high protection of metal against environmental corrosion. Geomet coatings were developed by Dacral Group of Companies based in France, USA and [7].

They are resistant to temperature up to 300 °C and do not show hydrogen embrittlement. Elements covered by Geomet coatings require cleaning before coating, but unlike other zinc flake coatings, they do not require phosphating. The application of Geomet coatings is carried out using three methods [7]:

- application in bulk in baskets by dipping and spinning the excess coating.
- immersion application for large or delicate elements, together with turning to remove the excess coating.
- spraying using traditional, electrostatic or automatic spraying techniques. This method can be used for partial coating of large components, e.g. brake discs, and even for components with cavities.

After each of the above mentioned coating processes, the elements are heated at 300 °C for curing.

Geomet coatings were developed to provide good corrosion resistance to steel elements, but they can also be used to cover other materials such as stainless steel to prevent pitting and crevice corrosion, and aluminium to prevent intermetallic corrosion. This type of coating is not used for copper and bronze [7].

Geomet coatings allow barrier protection, galvanic protection, passivation and self-regeneration. Barrier protection is the overlapping of zinc and aluminium flakes creating a barrier between the steel substrate and the corrosive environment. Galvanic protection, on the other hand, enables zinc to corrode, thus protecting the base substrate. Passivation protection consists in slowing down the corrosion reaction by metal oxides that slow down the corrosion of zinc and steel, causing much better protection against corrosion than pure zinc. Self-regeneration involves the movement of zinc oxides and carbonates to the damaged areas of the coating, thus repairing and renewing the protective layer. Asa result, coatings of this type provide corrosion protection in 600 to over 1 000 hours [7].

Coatings of the Geomet type have a silver-grey colour on the surface and, similarly to Zintek coatings, they can be covered with coloured organic and inorganic sealants.

The undoubted advantages of this type of coatings include their aesthetic appearance, material consistency, good adhesion to the substrate, the possibility of use for elements with plastic or glued additives, the possibility of grounding applications (the topcoat is not an insulator), and good bi-metal protection (especially of aluminium) [9].

It distinguish the following types of Geomet coatings – Geomet 321 and Geomet 500 (containing grease) [7].

The Geomet 321 coating can be used for extruded products, fasteners and large workpieces. It is applied if the corrosion resistance requirement exceeds 720 hours and has a sealed topcoat that can be greased if necessary. The Geomet 500 coating, on the other hand, is used to coat fasteners and small parts with a corrosion resistance of up to 600 hours and a typical coefficient of friction of 0,15 [7].

SALT SPRAY TESTING

The most popular method of anti-corrosion assessment is the salt spray method. This type of study was conducted by the authors [5] who tested coated steel parts in order to indicate the relative corrosion resistance of the protective layer. The tests were carried out in a salt spray chamber until the occurrence of white and/or red rust (corrosion of the metal base) according to EN ISO 9227 [9]. Zinc coatings applied by lamellar, electrolytic and mechanical fire methods were used for the tests [3]. Corrosion resistance was expressed in hours of neutral salt spray (h NSS), and the results of the tests are presented in Table 1.

Table 1 **Results of salt spray tests [4].**

Coating type	h NSS test for metal base corrosion (according to ISO 9227)
Electrical mechanical zinc plating with white, blue and black passivation	12 h – 72 h
Electrical mechanical zinc plating with yellow passivation	24 h – 144 h
Electrical zinc plating with chromium (III) passivation	24 h-360 h
Electrical zinc plating of chromium (III) passivated alloys	168 h-720 h and over
Lamellar	240 h-960 h and over
Hot dip	none

As can be seen in Table 1, lamellar coatings may show better NSS values than hot dip galvanised ones, but hot dip galvanised fasteners are more resistant to damage and friction [5].

SUMMARY

Legal conditions have forced the automotive, electronics and electromechanical industries to look for more ecological methods of applying protective coatings. Protective coatings with the use of zinc flakes undoubtedly satisfy such a need, as elements coated with zinc flake coatings have gained in popularity in recent years owing to very good results of corrosion resistance, as well as the low complexity of the production process and lack of environmental pollution. However, the undoubted disadvantage of the lamellar method is the possibility of covering elements with maximum dimensions up to 200 mm and low resistance to abrasion and damage of this type of coating. The strength of lamellar coatings, depending on their thickness, reaches 10 years.

It is expected that this type of coatings will also be used in other industrial sectors.

Acknowledgments

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Note: Nowak P. is responsible for English language, Katowice, Poland