

White Paper Think Zinc

The beginner's guide
to zinc thermal diffusion





White Paper Think Zinc

The beginner's guide to zinc thermal diffusion

Table of Contents

Introduction	2
Industry trends in metal refinement: why zinc thermal diffusion is meeting the challenges of the industry	3
6 Facts you should know about zinc thermal diffusion	4
Zinc thermal diffusion in comparison to other processes: answers to your most important questions	5
Which industries use zinc thermal diffusion?	7
10 Reasons you should think about using zinc thermal diffusion	8



Introduction

2.5 trillion US dollars - that was the estimate a study by Nace International gave for the costs of corrosion damage in key industrial areas. That corresponds to around 3.4% of the global gross domestic product. The good news is: Corrosion represents a huge potential area of savings around the world. According to Nace International, 15 - 35% of costs can be saved by using measures to protect against corrosion.

Zinc thermal diffusion offers a solution for long-lasting, reliable corrosion protection. This innovative technology helps companies avoid investments in replacement technology, losses of efficiency, or downtimes caused by corrosion.

Higher demands for economic efficiency, safety, and environmental protection are forcing many industrial fields to reassess the technologies and processes they have used in the past. Because of this, they're looking for solutions that make both good economical and ecological sense.

The zinc thermal diffusion process is one of the most modern and effective methods for protecting metals and metal products against corrosion, and makes a key contribution to tapping into new fields of application.

Are you looking for more information about the innovative technology zinc thermal diffusion?

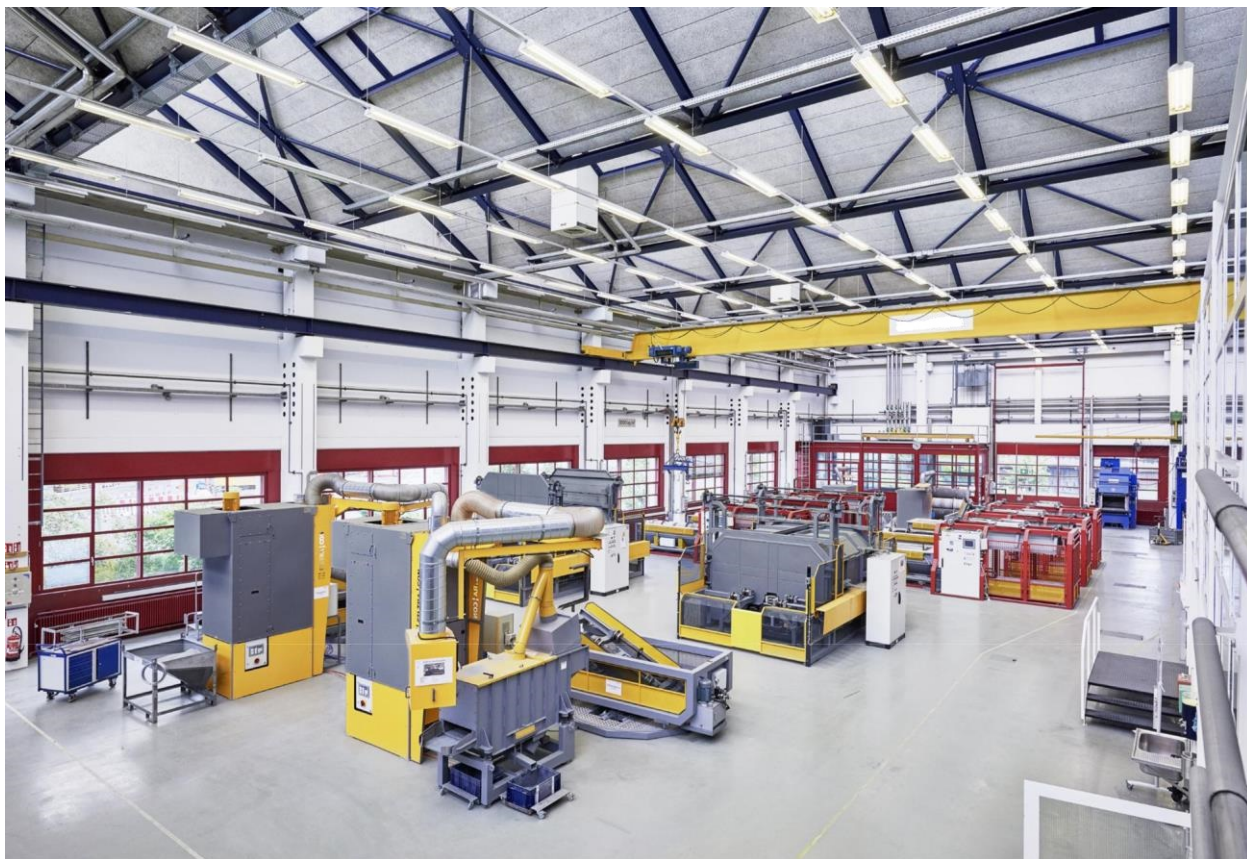
In this white paper, you will learn:

Why is zinc thermal diffusion meeting the challenges of the industry?

What makes zinc thermal diffusion different from other processes?

Why and in which industry is zinc thermal diffusion used?

Finally, the 10 most important arguments for using zinc thermal diffusion.



Zinc Thermodiffusion Production



Industry trends in metal refinement: why zinc thermal diffusion is meeting the challenge

How does an effective
coating technology pay off?

Population and economic growth, increasing mobility, and uninterrupted urbanization: we frequently hear reports on such trends and their influence on important areas of commerce and industry. But what do coating technologies like zinc thermal diffusion have to do with them?



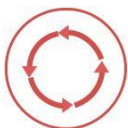
**High safety
requirements**

Bridge constructions, tunnels, and roads are reach or exceed maximum load limits much earlier than planned. New solutions are a necessity for components and their respective connecting and attachment elements so they can fulfill these changing conditions. Zinc thermal diffusion can handle such conditions, improving the properties of the base material to provide more security and reliability for treated components.



**Weight-saving
construction**

The demand for economical vehicle concepts and higher environmental protection requirements are forcing the automotive industry to find new solutions. Zinc thermal diffusion technology allows them to create smart material blends and use lightweight components. Different material combinations can reduce or avoid the danger of contact corrosion. Today, both of these can provide a key advantage over competitors.



**Lower life
cycle costs**

Increasing freight traffic, additional friction from high-speed trains, and denser timetables in urban centers have led to a systematic increase in wear to railway infrastructure in recent years. Many railway network operators are confronted with high expenses for replacement investment and maintenance. Coating technologies such as zinc thermal diffusion significantly extend the service life of the railway network, helping to lower costs.

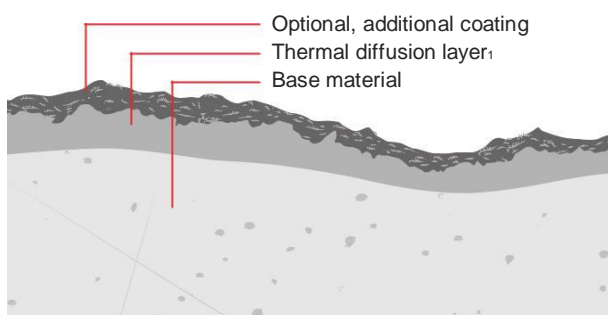


**Long service life under extreme
environmental and operation
conditions**

Connecting and fastening elements like screws, nuts, anchors, and threads are often installed in cavities and open spaces, and must handle a wide range of corrosive conditions. Because of this, highly resistant corrosion protection is a necessity. Zinc thermal diffusion offers the ideal solution, providing results that outperform those of other coating technologies by far.

6 facts you should know about zinc thermal diffusion

Zinc thermal diffusion is not a classic surface coating. While conventional processes simply apply a layer of zinc to a base material, zinc thermal diffusion binds the zinc to the base material, creating a resistant zinc-metal compound. This micro alloy process provides deep corrosion and wear protection, having a positive influence on the coating layer's hardness, wear-resistance, and further processing options like welding.



1 Thermal diffusion layer:
Micro alloy of zinc and base material

Zinc thermal diffusion is a thermal diffusion process

Metal products are heated with a zinc-powder blend consisting of zinc dust and additives in slowly rotating containers. The zinc reacts with the metal surface during the process. This creates a zinc micro alloy with a coating thickness of 4 µm to 25 µm.



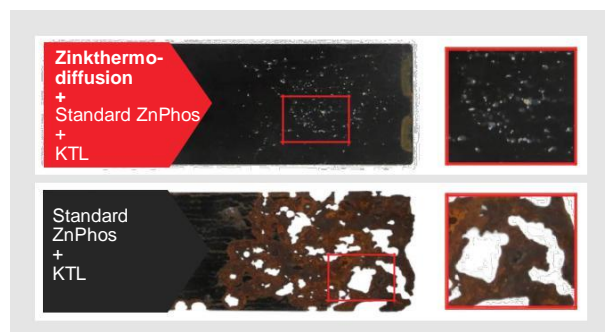
Zinc blend with additives in coating container

This process allows operators optimal control over the specific parameters

Depending on customer requirements, the coating thick-ness can be precisely controlled by varying the quantity of zinc dust, processing time, and temperature. Parameters like elasticity, ductility, or harness can also be changed to suit customer needs.

Zinc thermal diffusion can even be used on damaged surfaces

Externally validated tests prove: zinc thermal diffusion provides intact corrosion protection even on damaged material surfaces, standing out for its excellent resistance to stone chipping and other influences. External tests also show no infiltration by rust even after 180 cycles (corresponding to approx. 15 years of field testing) and even on previously damaged test parts.



External test (SAE J2334) validation completed by
BASF Automobile Solutions

The zinc thermal diffusion process can be used within an optimal temperature range. Ideal processing temperatures of 280°– 390°C allow even sensitive components to be treated without negatively affecting their material properties. Hydrogen embrittlement can be avoided by using a dry oven process with zinc thermal diffusion.

Very good price-performance ratio in relation to corrosion protection

Standard tests by Atomic Alloys have shown results of 3,000 h or better in salt spray testing. This is far better than coating technologies currently in use.



Zinc thermal diffusion in comparison to other processes: answers to your most important questions

Why is the optimal process temperature so important?

Coating is completed at a process temperature of 280°–390°C in the zinc thermal diffusion procedure. The zinc can combine optimally to the base material in this temperature range. This creates a resistant micro alloy offering a high level of corrosion protection. Lower processing temperatures, such as with zinc flake coating (approx. 200°C) frequently lead to insufficient adhesion between the coating and base material. This results in the zinc layer flaking off, ultimately causing corrosion.

The high processing temperature of 450°–600°C used in hot-dip galvanizing, in contrast, has a negative influence on the mechanical properties of the base material. Processing temperatures in sherardizing are also often over 400°C, which can lead to a loss of structural stability with previously hardened components. In addition, there is the danger of coated components warping or bending.

Zinc thermal diffusion is a gentler process for materials, increasing the elasticity and/or ductility of the original material and minimizing the risk of crack formation and material failure significantly.

Is there danger of hydrogen embrittlement?

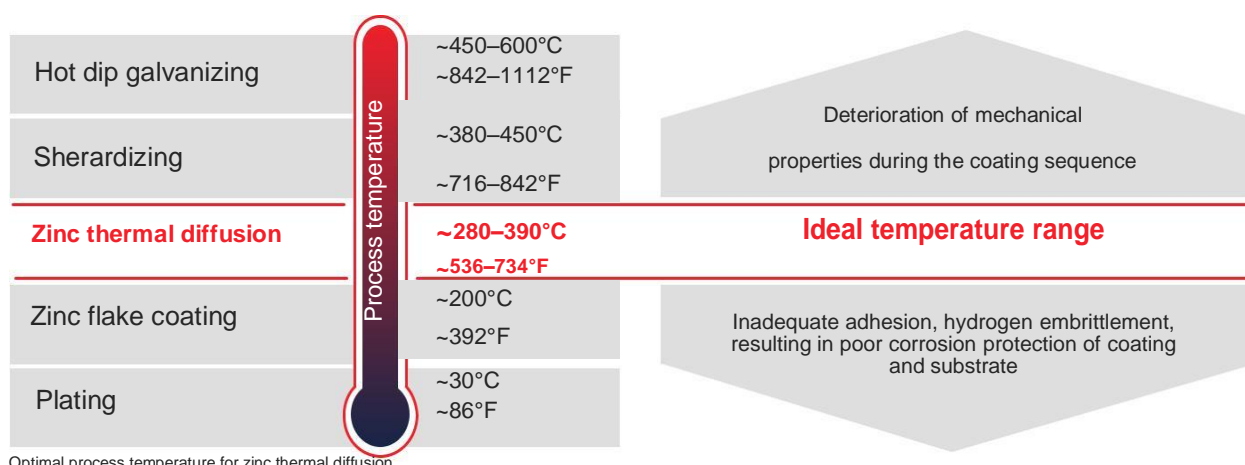
Thanks to the dry oven process used in zinc thermal diffusion, there is no risk of hydrogen embrittlement. Aqueous systems are often used in galvanic coatings, in which hydrogen can diffuse into the base material. This can lead to embrittlement in the components. As material strength increases, the risk of hydrogen embrittlement also increases.

Therefore, aqueous electroplating coatings cannot be used without heating for steels over 1,000 Mpa. This additional process step is eliminated when using the dry zinc thermal diffusion process.

Is the zinc thermal diffusion process harmful to the environment?

Because it does not involve chromium-VI and CMR materials (carcinogenic, mutagenic, reproduction toxic substances), the zinc thermal diffusion process does not pose any contamination hazard to employees or the environment. All materials used in the process are also recyclable and not subject to any special disposal requirements. Disposing of bath materials used in galvanizing, for instance, is much more complex.

Closed systems allow the thermal diffusion equipment to be operated without any emissions or wastewater production. The hot dip galvanizing process is less environmentally friendly. Processes associated with hot dip galvanizing frequently produce dust, hydrogen chloride, and wastewater.





What is the range of the coating thickness?

During the zinc thermal diffusion process, zinc reacts with the metallic surface of the base material. This creates a micro alloy with an even coating thickness of 4 μm to 25 μm . Depending on customer requirements, the coating thickness can be optimally adjusted by varying the quantity of zinc dust, processing time, and temperature.

Zinc flake coatings are very thin, at 8 μm –15 μm , but are simply applied as a layer on the base material. Corrosion protection in zinc flake coating is far inferior to the resistant micro alloy created in zinc thermal diffusion.

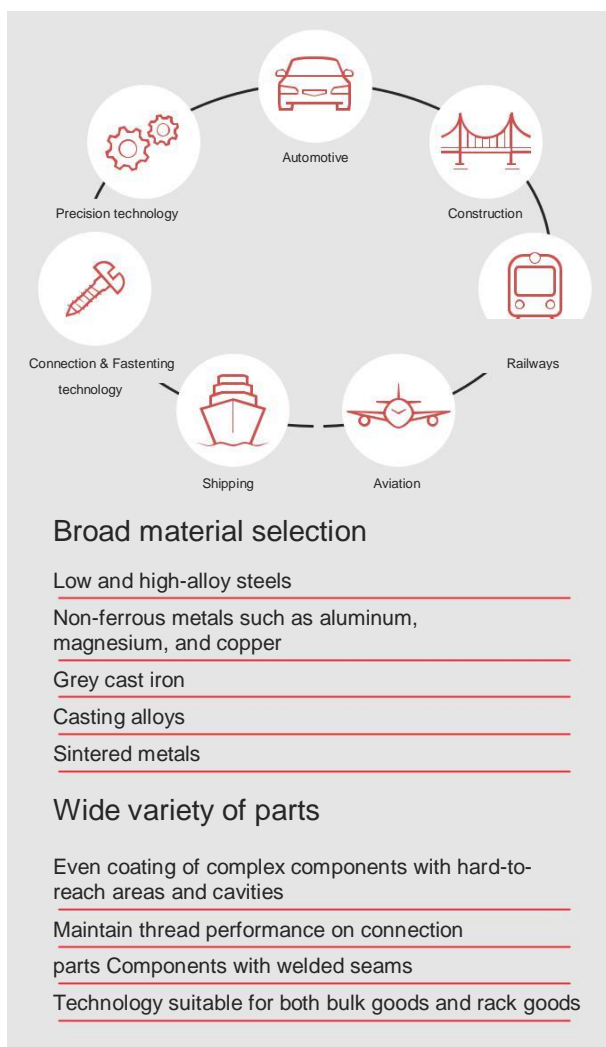
Both hot dip galvanization and sherardization, in contrast, a thick and uneven layer, typically >50 μm , which can be problematic in many areas. Especially in precision technology and in connection and attachment technologies, an even fine layer coating is essential to ensure that the component volume does not increase too greatly.

Thick coating layers are also often associated with an increase in ductility and brittleness.



Which industries use zinc thermal diffusion?

The zinc thermal diffusion process is suitable for a wide variety of materials. The gentle, container-based process allows for even coating of complex components, hard-to-reach areas, and cavities. The technology allows operators to maintain thread performance on connection parts, and protects components with welded seams. Zinc thermal diffusion can be used with diverse materials and parts, and is also optimal for treating bulk materials and rack materials.



Application examples for structural steel

Structural steel, for instance, is very well suited to zinc thermal diffusion. Low-carbon structural steels are used in most industrial sectors. From suspension plates and underframe guards for the truck industry, to consoles and threaded sleeves or motor struts in cars, hybrid clutches and bell cranks for the railway industry can also be coated.

Heat-treated steel for diverse applications

Heat-treated steel is characterized by high tensile and fatigue strength. The processing temperature used in zinc thermal diffusion is set at the optimal level to avoid a decrease in hardness, depending on the annealing temperature. Zinc thermal diffusion is used in many different kinds of applications. Screws, anchor bolts, or cup springs are coated in mechanical engineering applications. Besides the automotive industry, this steel is also used, for instance, in clamping cylinders and sleeves in the offshore sector.

Machining steel pressed parts

Besides cold formed pressed parts like belt holders, exhaust mounts, or brackets in automotive applications, many customer projects involving machining steel have also been coated using zinc thermal diffusion. The process is optimized for precision machining production processes on automated tooling machines. The primary application areas include series production on turning machines and combined processing centers. Brake parts for crane equipment, knurled nuts, and screw fittings in machine construction or ball sockets and bushings on vehicles can be easily coated.

Cast parts with high carbon content

Cast parts can also be coated with zinc thermal diffusion. So-called gray cast iron is an iron-carbon alloy with a high percentage of carbon (>2%). Classic applications include brake calipers or pivot bearings in the automotive industry.

Many other potential applications

These are just some examples of applications for patented zinc thermal diffusion technology, which can also be used to coat non-ferrous materials like aluminum, magnesium, or copper. This broad range of materials and components covers all key industrial sectors. A trained team of expert specialists is working continuously to improve this technology, offering customer-specific solutions for each new application.



10 reasons you should think about using zinc thermal diffusion

1. Patented technology

The patented process by Atomic Alloys offers long-lasting corrosion protection, providing new opportunities to blend materials. The ideal processing temperature of 280°– 390°C offers customers the best possible combination of long-lasting corrosion protection and improved mechanical properties.

2. Durable protection against corrosion at the best price-performance ratio

Zinc thermal diffusion offers very good corrosion protection in relation to its price. Standard tests have shown results far superior to current common coating technologies (3,000 h in SSNT and more). Depending on customer requirements, corrosion protection can be adjusted optimally for each application by controlling processing parameters.

3. Best possible surface quality

Simpler welding processes and ideal coating properties for adhesive or paint layers allow customers to optimize costs and processing times. Increased wear-resistance and resistance to impacts and damage simplify logistics and transportation. In addition, very little transport protection is necessary, since small areas of surface damage do not interfere with corrosion protection.

4. Improved material properties

Material requirements in lightweight construction confirm the need for high-quality surface coatings such as Atomic Alloys technology. The coating technology offers increased strength under higher structural loads. This allows the use of thinner-wall steel.

5. New material combinations

A smart blend of materials can be a significant advantage over the competition in many industries. Atomic Alloys provides a key competitive advantage: the technology prevents contact corrosion between different materials, eliminating additional separating elements used to avoid contact corrosion.

6. Protection for the base material

The dry zinc thermal diffusion process allows customers to avoid the danger of hydrogen embrittlement. In addition, the process increases the elasticity and/or ductility of the original material, which clearly minimizes the risk of crack formation and material failure. Because of this, the process is especially well-suited to components subject to the highest safety requirements.

7. One process step – infinite variety

The Atomic Alloys technology is well-suited for low and high-alloy steels, non-ferrous metals, alloys, or for cast, forged, and sintered components. Even complex geometric parts like uneven surfaces or hard-to-reach areas can be coated evenly in just one process step, without mechanical reworking.

8. Custom product finish

Atomic Alloys offers custom-tailored solutions and a specific finish for each product portfolio. Our experts advise customers, presenting various sealing options and top coats by the brand TD Excel®.

9. Turnkey total solutions

Atomic Alloys offers its customers the “Flexibility” and “Capacity” system concepts, with customized designs and a broad range of applications. Turnkey production lines and associated licenses allow our customers to take the reins in handling their projects.

10. Sustainable and certified production process

Atomic Alloys has implemented a quality management system in accordance with ISO 9001:2015 to apply our quality guidelines. Atomic Alloys coating technology offers solutions that fulfill the highest requirements related to safety and environmental protection. The production process is environmentally-friendly and entirely free of chromium VI and toxic substances.



Sources

Donner, S. (December 3rd, 2009). Rust destroys three per-cent of GDP annually. Accessed from <http://www.tagesspiegel.de/wirtschaft/studie-rost-vernichtet-jaehrlich-drei-prozent-des-bip/1641884.html>

Maas, P., & Peissker, P. (2008). Handbuch Feuerverzinken. Weinheim, Deutschland: Wiley-VCH

Koch, G., Varney, J., Thompson, N., Moghissi, O., Gould, M., & Payer, J. (2016). International Measures of Prevention Application, and Economics of Corrosion Technologies Study. (Nace International). Accessed from <http://impact.nace.org/executive-summary.aspx#>

Selent, J. (2014). Zinklamellen-Beschichtung Hochleistungs-Korrosionsschutz für Seecontainer. Journal für Oberflächentechnik, 54(16), 22-23

SH. (December 18th, 2009). Gefahr für Wirtschaft und Umwelt durch Korrosion. Accessed on April 18th, 2017 from <http://www.jot-oberflaeche.de/Nachricht/11055/Gefahr-fuer-Wirtschaft-und-Umwelt-durch-Korrosion.html>