

# Setting new horizons in electroplating of zinc die castings

*Our supply of zinc, a metal abundant in our planet's crust, could run out by 2100 unless we begin to change the way we use it. Collini Holding AG creates a step change in uncovering and addressing the core causes of common faults of plating on zinc die cast by investigating this material and the ways of its surface finishing in a more sustainable way.*

With over 7 billion people on the planet – theoretically from today – there will be an inevitable increase in the demand on the world's natural resources. Natural gas, oil, and coal are some of the key natural resources that are in danger of being diminished. Yet, there are additional resources provided to us by our planet that although their existence is an integral part of our daily lives, they will eventually vanish; that is unless we begin to change the way we use them.

Zinc and its alloys are essential to manufacturing processes because of their respective properties such as castability and performance while also offering significant energy and cost savings. However, this metallic element is a profound example of a vanishing natural resource because its supply from our planet's crust is predicted to last only until 2100. This is exactly why

Collini Holding AG, the leading group of companies in coating metals and plastics in Europe, has been investigating and developing surface solutions to render zinc alloys more sustainable and efficient. Founded as a grinding shop over 120 years ago, Collini is now an industrial surface treatment company, creating surfaces for fittings, electrical and automotive industry, machine, plant and building construction, and also for medicine and various consumer goods. The company has thirteen production sites in Austria, Germany, Italy, Russia, Mexico and Switzerland that specialise in a wide range of surface technologies including electroplating, hot-dip galvanizing, anodizing and organic coating.

## ZINC DIE CASTING

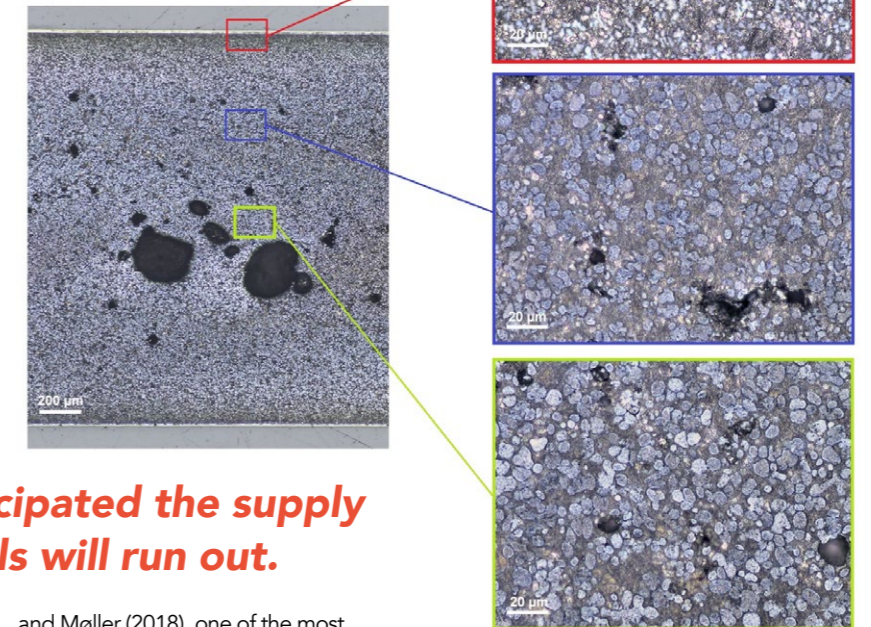
From toy cars that children play with to the metal parts used in actual cars, there is a huge variety of consumer parts made using the die casting process. In fact, die casting is a manufacturing process that has been around for more than 180 years and was initially invented in order to develop portable typewriters. Essentially, this process involves heating metal alloys until they become molten and consequently pressed between steel moulds until they cool down and solidify in the required shape. One of the most popular alloys to use in the die casting process is zinc alloys because they are easier to cast and solidify at a lower temperature in comparison to alternatives such as aluminium, therefore, the die casting process is cheaper and more efficient.

Zinc is a hard, ductile, self-lubricating material that has high thermal conductivity and dimensional stability. However, unalloyed zinc is brittle, is weaker and it is susceptible to corrosion in acidic and/or

strong alkaline environments. Therefore certain elements, like aluminium or copper, are added to obtain zinc alloys with superior properties. Although, adding those dissimilar elements opens the way to corrosion, a process of metal deterioration. In this way, electroplating coatings are a necessity in order to change surface properties: reduce metal cations from a solution with the help of electric current, and hence form a protective metallic coating. Furthermore, and disregarding the long usage of electroplating as the surface treatment for it, zinc die casting persistently generates several challenges for plating, especially when it comes to decorative use (Reveko and Møller, 2018). Consequently, there are a variety of challenges associated with zinc die casting that has recently become the primary research of the Austrian surface treatment company Collini Holding AG in

## SPECIAL ASPECTS OF ELECTRODEPOSITION ON ZINC DIE CASTINGS

Zinc die casting part in cross section: difference in structure between the surface and the bulk.



**By 2100, it is anticipated the supply of most metals will run out.**

conjunction with the Technical University of Denmark (DTU). Their work has resulted in the completion of a series of studies by Collini scientist Valeriia Reveko.

## ZINC PLATING COLOUR CHANGE

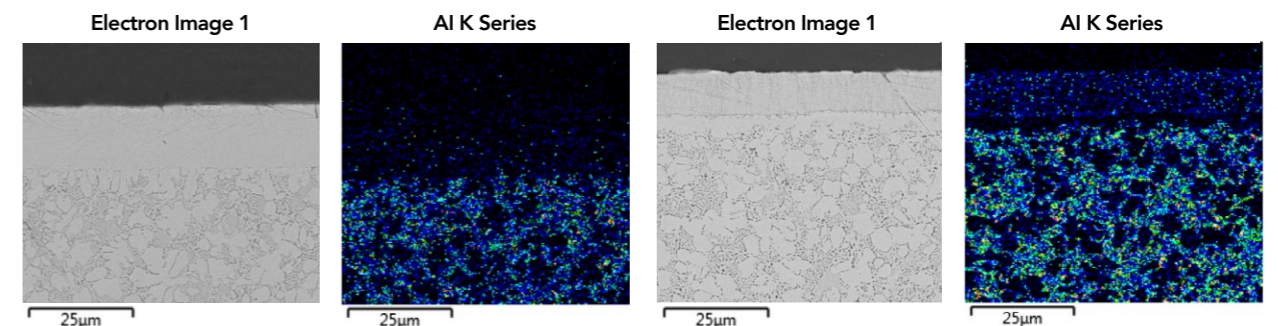
Valeriia Reveko, a PhD candidate in the Department of Mechanical Engineering, DTU, has published several peer-reviewed research studies that highlight the distinct challenges that are associated with the electroplating of zinc die-casted parts. More specifically, Reveko has conducted thorough morphological and compositional tests and analyses to verify the performance and safety of zinc galvanic coatings on zinc die-cast items to improve the plating quality. For instance, and as noted in Reveko, Lampert, Winther

and Møller (2018), one of the most common issues with zinc coating over zinc die-cast components involves a distinct blue discoloration – blue areas on the surface of the electroplated zinc coatings. In this study, Reveko and co-workers suggest that aluminium from the substrates will gradually diffuse through the coating and will propel the manifestation of these blue areas as a result of oxidation under the influence of ambient moisture and potential contaminants. Furthermore, and perhaps more importantly, the environment within which zinc plating occurs – from alkaline or acidic solution – directly influences the rate of aluminium diffusion: alkaline zinc demonstrates higher rates of diffusion compared to acidic zinc due to its

morphology. Hence, and as suggested by Collini team, a viable and attractive solution can be a double-layered zinc coating in which the inner layer is mildly acid zinc and the outer layer is alkaline zinc.

## INACCURATE ANALYSIS OF CHROMIUM-PASSIVATED ZINC SURFACES

In principle, trivalent chromium conversion coating is a very efficient way to anticipate corrosion of zinc coating while meeting environmental and safety requirements. However, some recent research studies reported the presence of hexavalent chromium in the surface passivation layers.



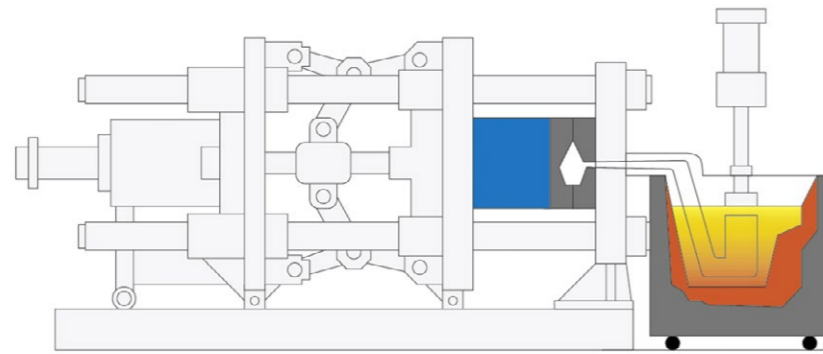
Scanning electron microscope images with Energy-dispersive X-ray spectroscopy analysis showing Al presence in zinc plated, zinc die-casted component before (left) and after (right) blue discoloration.



The Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) has banned hexavalent Cr coatings because they are carcinogenic. In addition, 4% of people in Europe and 5% in America are allergic to chromium, and hexavalent Cr is much more likely to cause a skin reaction such as dermatitis than the trivalent one.

In general, colourimetric 1,5-diphenylcarbazide (DPC)-based spot test is one of the principal methods used to identify hexavalent chromium on various metallic and leather surfaces. However, and as noted in Reveko, Lampert, Din, Thyssen and Møller (2018), DPC testing on trivalent chromium

### ZINC PRESSURE DIE CASTING Conventional Hot Chamber Machine



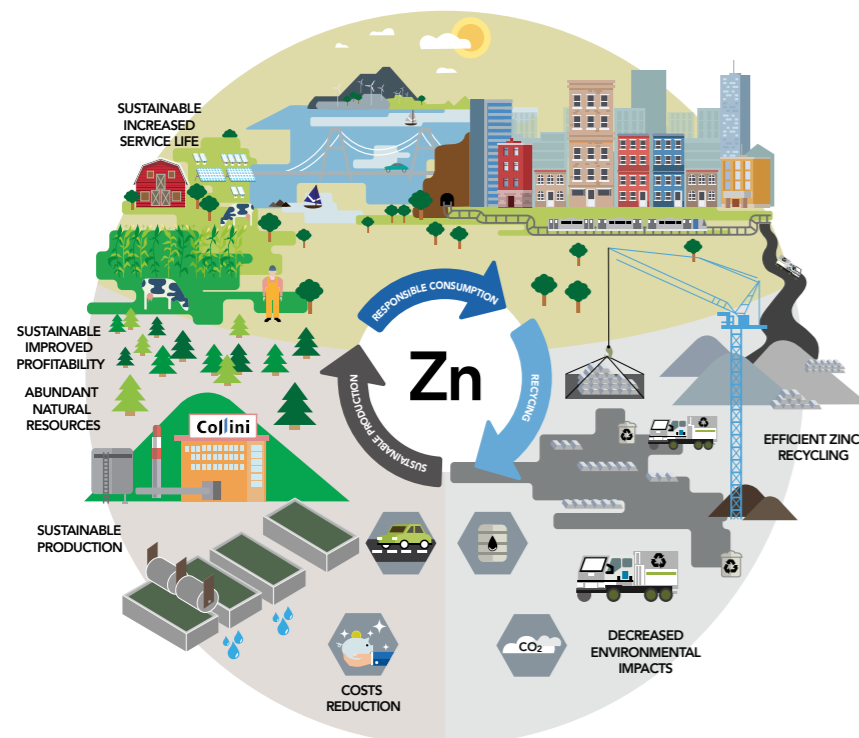
Zinc die casting machine.

## Research in Collini intends to reveal and address the causes of common plating faults and support sustainable use of materials.

passivated zinc surfaces can actually be misleading. X-ray photoelectron spectroscopy (XPS) measurements performed in this research study did not verify the presence of hexavalent chromium previously identified on such surfaces by DPC. The study suggests that unintended oxidation of the DPC indicator in reaction with the substances present

on the surface because of atmospheric corrosion can be the reason for these false-positive results. The importance of this study is not limited to the impeccable level of quality control needed in the European metal industry, but also because these false-positive results can unavoidably result in the prescription of erroneous treatment to patients with contact dermatitis.

### ZINC RESPONSIBLE USAGE CYCLE



### SUSTAINABLE SOLUTIONS

This research would be remiss if it did not consider the present-day ecological sustainability challenges. Coated metal alloys consist of parts with multiple coating layers of different metals that are tricky to recycle. This is because separating metals such as chromium and nickel – metals that are traditionally used to coat zinc metal alloys – is a process with increased energy demands. Therefore, researchers have shifted their focus on coating zinc alloys with zinc coatings because this process reduces the overall number of metals used, thus rendering the recycling process easier. This is exactly why Collini has turned its attention towards improved approaches of the surface treatment of zinc die-cast parts. The usage of recycled zinc is an energetically favouring process because its energy requirements are less than 10% compared to the production of primary zinc. Essentially, the research presented in this article is directly connected to the increasing industrial need for recyclable zinc components.

### CONCLUSIONS

This research conducted by Collini intends to identify and evaluate the core causes of common plating faults while supporting the sustainable use of materials. Valeriia Reveko's study provides greater insight into the electroplating of zinc die castings while at the same time, it manages to evaluate the hidden challenges of zinc-plated and zinc die-casted components, and trivalent chromium-passivated zinc surfaces.



# Behind the Research Valeriia Reveko

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### Research Objectives

PhD candidate Valeriia Reveko from the Austrian electroplating company Collini, has completed a series of studies looking into how to make the usage of zinc more sustainable.

### Detail

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### Bio

Valeriia Reveko is a Product- and Process Development engineer in Collini GmbH, Austria. She holds an MSc degree in technical electrochemistry from Kiev Polytechnic Institute and is conducting a PhD project in materials science and surface technology at the Technical University of Denmark (DTU).

### Funding

The research was funded by Collini GmbH, Hohenems.

### Collaborators

- Professor Per Møller, Technical University of Denmark (DTU).



### References

Valeriia Reveko and Per Møller (2018). 'Special Aspects of Electrodeposition on Zinc Die Castings'. *NASF Surface Technology White Papers*, 82 (8), pp. 1-9, [Article Post: 3/19/2018](https://doi.org/10.1007/s40962-018-0237-0).

Valeriia Reveko, Felix Lampert, Grethe Winther and Per Møller (2018). 'Change of The Decorative Properties Of Zinc-Plated Zinc Die Castings Over Time'. *International Journal of Metalcasting*, pp. 1-7, <https://doi.org/10.1007/s40962-018-0237-0>.

Valeriia Reveko, Felix Lampert, Rameez Ud Din, Jacob P. Thyssen, Per Møller (2018) 'False-positive result when a diphenylcarbazide spot test is used on trivalent chromium-passivated zinc surfaces.' *Contact Dermatitis*, Volume 78: Issue 5, pp. 315-320, [doi:10.1111/cod.12955](https://doi.org/10.1111/cod.12955).

### Personal Response

#### Why do you think it's important to find ways to recycle zinc?

It is my position that in today's world, we cannot continue to use natural resources in such an exploiting manner as we currently do at the moment. Our planet has given us a great deal, and the least we can do in return is to use these resources wisely. Zinc, copper, nickel, steel, aluminium, plastic – before putting those materials to the market, we must carefully consider the whole product lifecycle, aiming for sustainable solutions; and the surface treatment industry can be a conductor who make a real impact on this.

'Applied surface intelligence' is the motto at Collini, and we all work together with the aim of using materials more effectively.

