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Improving corrosion protection through constructive measures

QIB
Qualitätsgemeinschaft Industriebeschichtung

Content

1. Introduction

In modern production processes, the manufacturing of components is often planned and carried out in different departments or process steps. A holistic consideration or quality planning rarely takes place with regard to the selection of the manufacturing processes and the working steps. Through a holistic process consideration in the production of parts, the quality can be increased significantly. In the complete process, suitable actions can be taken in advance to minimize complaints about coated parts at a later stage. This brings great potential for savings. This leaflet is intended to show specific actions and possibilities to improve the quality of the construction and with it the corrosion protection in the long term.

Typical problems with the coating result are due to the following issues:

- construction
- oxide layers and scale layers
- pretreatment process
- sharp edges
- mechanical preparation
- layer thickness

2. Construction

A significant part of the success of an organic corrosion protection system is already contributed by the construction. The design department must avoid folds and doublings and construct joints in such a way that reachability is guaranteed. For example, so-called welding feet can be used to avoid gaps. Defined suspension points allow the weak point "suspension point" to be determined specifically. At the same time, the drainage holes necessary for chemical pre-treatment can be placed correctly. By involving the coater at an early stage, significant cost savings can already be realized at this stage, for example, by better utilisation of hangers or by eliminating additional services such as priming and sealing.

Typical sources of error:

- folds
- material doublings
- lack of accessibility of surfaces
- missing or incorrect coating instructions
- gaps and joints
- inaccurate process planning
- procedural error points
- corrosion protection requirement was not defined exactly

Figure 1: Welding foot: correct design on the left; risk of corrosion due to gap on the right

3. Oxide layers and scale layers

Any heat treatment close to the melting point of the metal produces scale layers in combination with oxygen. Any oxide layer and scale layer extremely decreases the corrosion resistance. Therefore, when purchasing, make sure that the material is free of scale, such as cold-rolled blank steel or material that has been blasted at the factory.

Laser processing produces laser scale on oxygen-lasered sheets, and welding produces welding scale. Water-jet cut sheets often show flash rust, which is caused by contact with water from the cutting jet.

Oxidation and rust formation must also be prevented during storage and transport of the parts.

Practical Tip - Descaling of workpiece edges:

Rust and scale-free products and processes are to be preferred. Descaling and plastering should be planned into the production process.

Figure 2 (left): Mill scale and corrosion on raw materials

Figure 3 (right): Welded part with scale and grease burn-in

Descaling on edges and welds can be performed with tools. Deburring machines can be used to remove the scale produced during laser flame cutting. This is done with wire brushes of various designs. Thinner sheets are often cut with nitrogen (laser fusion cutting), in which case no scale is formed. Chemical pickling processes can be used to remove rust and scale. The processing time should be taken into account, which can be several minutes to hours.

Figure 4 (left): Angle grinder with cup brush

Figure 5 (right): Wire brushes for descaling

Another alternative to remove the scale is manual or automatic blasting. In this way, components can be freed from scale and prepared for coating. However, it is still necessary to round the edges, because blasting at best breaks the edges but does not round them.

Figure 6 (left): Sandblasting in the open jet house

Figure 7 (right): Roller blasting unit

4. Edges

Every metal cut creates an edge. The most common cutting techniques produce a similar edge profile. The cutting medium enters from the top, followed by a flank and ends with a burr at the exit point.

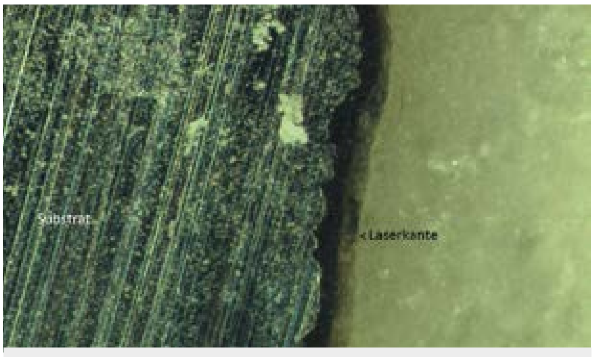


Figure 8 (left): laser edge

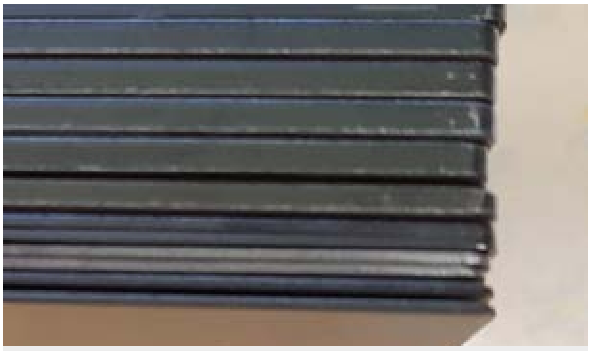


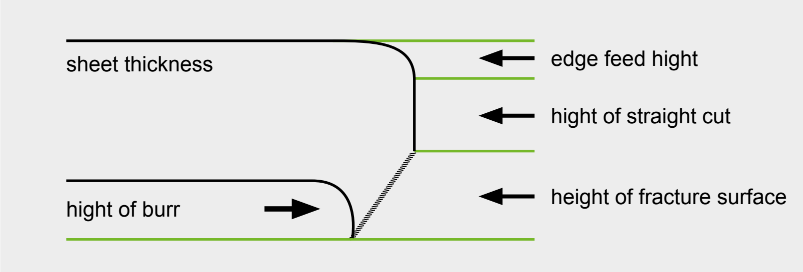
Figure 9 (rechts): laser edge with scale

- In punching and cutting, the penetrating tool produces a rounding on the surface, followed by a cut surface that ends in a burr above a fracture edge.
- In the case of laser and plasma cutting, the high heat input additionally produces an edge surface hardening and, depending on the gas used, a bluish oxide layer.
- Waterjet cut edges show a similar burr formation at the exit point. With larger sheet thicknesses, the cutting edge is profiled and shows a downward flare.

The properties of the cut edges are described in VDI leaflet 2906. A burr on the underside is characteristic for all processes. Depending on the process, this burr is between a 1/10 mm for punching to several mm for oxyfuel or plasma cutting. Laser cuts can be burr-free at best, but even a 90° edge is too sharp for a perfect coating.

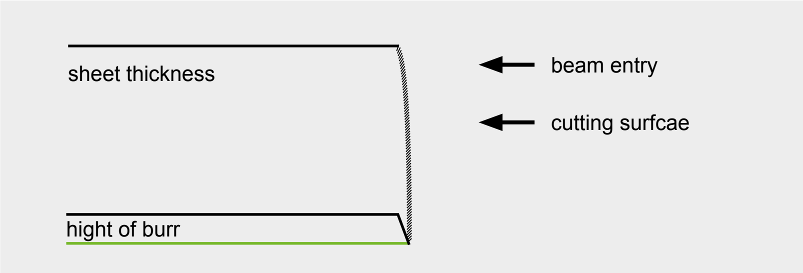
Shere cutting

(Source: Matthias Bader / Bader Pulverbeschichtungen GmbH)



Waterjet cutting

(Source: Matthias Bader / Bader Pulverbeschichtungen GmbH)



Laser cutting

(Quelle: Matthias Bader / Bader Pulverbeschichtungen GmbH)

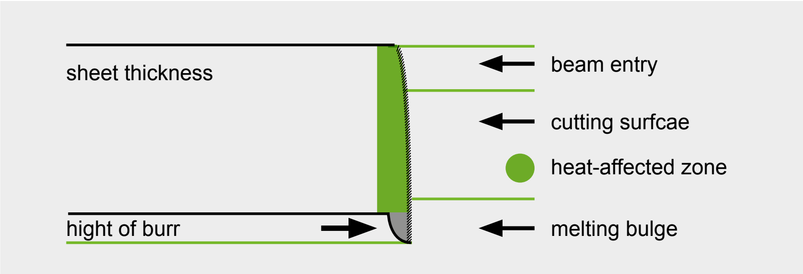


Figure 10: Scheme of burr formation with different cutting methods

A laser scale layer on the material edges, cut by means of oxygen without having previously removed it mechanically or with acid delaminates over a large area under load at the edge. The typical weak point in the coating of edges is the so-called edge alignment.

Figure 11: Test sheet with chipped coating on the laser edge

„Knowledge of physical effects helps to avoid coating defects. Rust usually starts at the edges and is often a result of physical effects. After all, in most cases there is an undercoating of the edge, which is a result of high surface tension of the coating material. And, after all, high surface tension is characterized by the liquid's effort to keep its surface as small as possible. This is achieved when the coating is pulled back from the edge.“

Source: Dr. Roland Somborn, Farbe & Lack, 8/2007 p. 47 Vincentz Verlag

Figure 12: Bicycle stand with spalling and corrosion at the laser edge

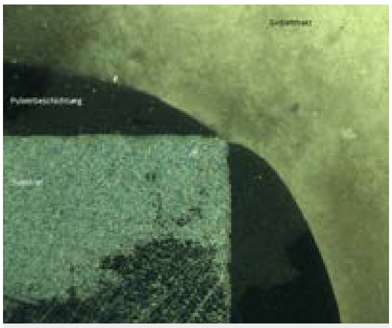


Figure 13: Edge alignment

Figure 14: Damage caused by insufficient layer thickness at the edge

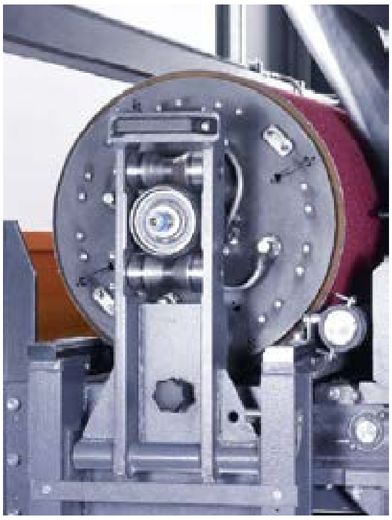
5. Mechanical preparation

In order to significantly improve the corrosion resistance at the edges, it is absolutely necessary to specifically machine the edges. This can be done manually or mechanically. Here, we will first present the processes that can be used for economical deburring of sheet metal blanks.

5.1 Aggregates for deburring:

For deburring, i.e. the removal of the (protruding) primary burr, there are three types of grinding units that are generally used today:

1. Broad belt unit
2. Transverse grinding belts
3. deburring rollers



5.2 Tools for rounding:

While the risk of (cut) injury on sheet metal can already be eliminated with a mitigation below 1/10 mm, a significantly higher rounding is required if a sufficient layer thickness is to be produced on the workpiece edges during coating. The rounding of edges is currently gaining in importance, since more and more companies are realizing the direct relationship between edge rounding and corrosion protection. Depending on the coating colour, the steel "shines through" at the edges when the layer thickness at the edge drops to a few µm due to the edge alignment. Today, three types of grinding units are generally used for rounding:

1. Grinding flap roller
2. Cup brush (plate brush)

Figure 18: Grinding flap roller (source: www.blech-entgratung.de)

Figure 19: Cup brush (source: www.blech-entgratung.de)

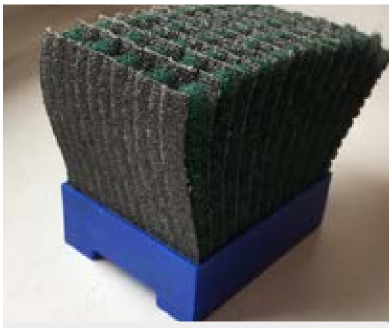


Figure 20: Grinding block (source: www.blech-entgratung.de)

It is important to recognize that not all tools and machine concepts are suitable for achieving equally good rounding!

This is obvious with transverse brushing machines, because the tools always come from one direction and consequently strike the longitudinal edges of the workpieces, where a significantly higher rounding is achieved than on the transverse edges, where the tools only brush past. But even cup brushes connected in series or cup brushes in planetary gears do not ensure that the rounding is equally good. The kinematics of the machine is the decisive factor here. Some producers therefore developed a system (partly with flap rollers, partly with revolving cup brushes) that handles all workpiece edges equally. In principle, the rounding tools shown can be used to produce a radius of 2 mm (thick-walled components). With thin-walled material (thin sheet), in particular, the maximum achievable edge radius depends on the thickness of the material. The removal volume increases as the square. Effective edge rounding occurs from 0.5 mm. Rounding to a radius of 2 mm (as required by the DIN EN ISO 12944 and EN ISO 1090 series of standards) thus increases the removal volume by a factor of 16.

5.3 Constructive preparation

Not all sheet metal components are designed to be rounded. The rounding of small holes is weaker than that of large holes, and internal corners, especially those at right angles or with an acute angle, are also rounded to a lesser degree.

Figure 21: Small bores and cut-outs are difficult to round

This can be remedied by maintaining a minimum radius of 8-10 mm when drilling. Cut-outs with "corners" should be avoided if possible. Since work is only carried out from the surface, the thickness of the workpiece has no influence on these radii.

5.4 Determination of the rounding intensity

The degree to which the edges of sheet metal are rounded can be measured. In the simplest case, measuring magnifiers with an integrated 1/10 mm scale are used. This allows an indicative determination of the rounding, even if it cannot be detected whether it is a radius, a chamfer or another course of the contour.

In a destructive test, an edge can be embedded in casting resin and a cross-section created. The edge contour can be evaluated in the microscope.

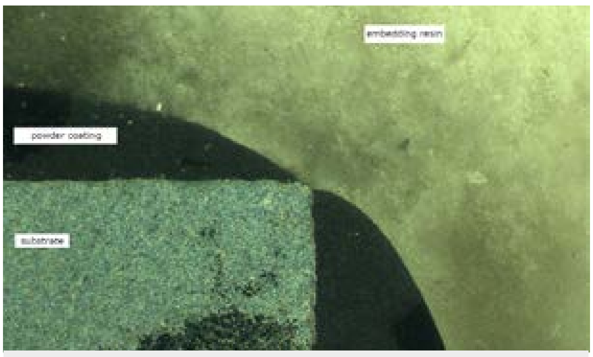


Figure 22: Cross section: edge alignment

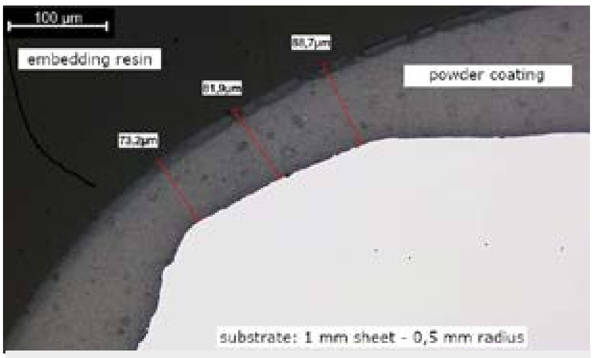


Figure 23: Cross section: rounded edge of thin-walled component (radius 0.5 mm)

5.5 Different type of parts

Whether it is plasma, oxy-fuel or laser parts is basically irrelevant for the task of edge rounding. The series of standards DIN EN ISO 12944, DIN EN 1090-2, and DIN 55633 applies to components in steel construction with a wall thickness of more than 3 mm. According to the standard, radii of at least 2 mm must be produced, depending on the corrosion protection to be achieved.

5.6 QIB test on structural corrosion protection

Oxygen cut sheets show a clear improvement with rounded edges, but corrosion starts very early at the scale edge. This leads to large-area delamination and corrosion formation.

For nitrogen-lasered sheets, a very good result was achieved after 500 hours in the neutral salt spray test (NSS). For comparative samples without edge rounding, the NSS was already terminated after 250 hours due to full adhesion

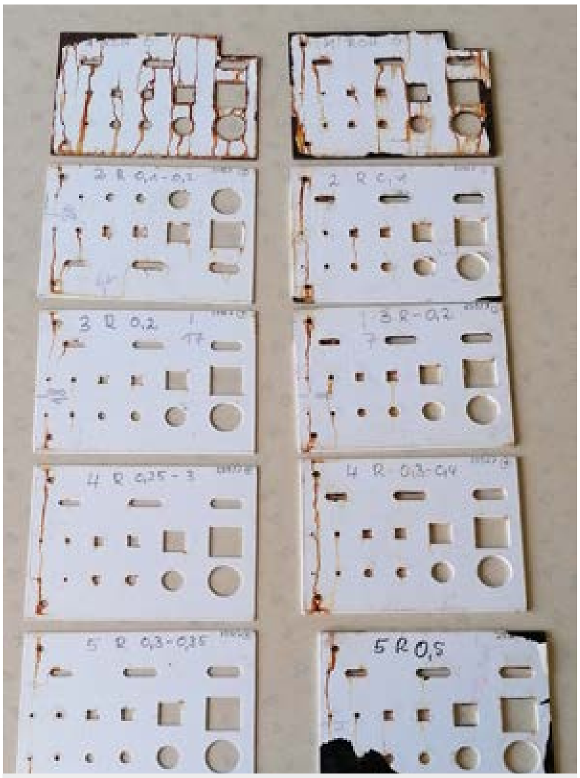


Figure 24: Test of edge rounding on laser-cut sheets with oxygen

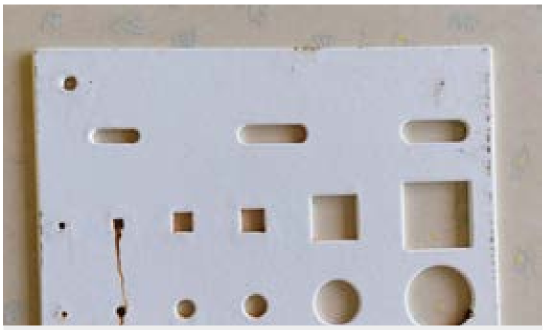


Figure 25: Test piece with rounded edges (0.5 mm); after 500 h NSS only minor signs of corrosion

Figure 26: Test piece without edge rounding; full delamination after 250 h NSS

5.7 Expenses

Of course, deburring and rounding costs money. Compared to manual processes, machine deburring and rounding is efficient and delivers reproducible results. The cost of machine processes is in the range of 2 - 6 €/sqm of material processed. This takes into account all costs such as depreciation, labour costs of the operator, tools, imputed rent for the floor space, maintenance, etc.

6. Pre-treatment process

Pre-treatment can be mechanical, chemical or a combination of these. The goal is a surface that is ready for coating.

6.1 Chemical pre-treatment

During chemical pre-treatment, suitable chemicals are used to degrease and clean the surface. By means of appropriate chemicals, a pickling attack can take place, which activates the substrate surface. The conversion layer or passivation is layer-forming in the micro- or nanometre range.

Figure 27: Unit for chemical pre-treatment

The degreasing effect can be tested by means of the **wetting test** or so-called test ink. The surface tension achieved is measured.

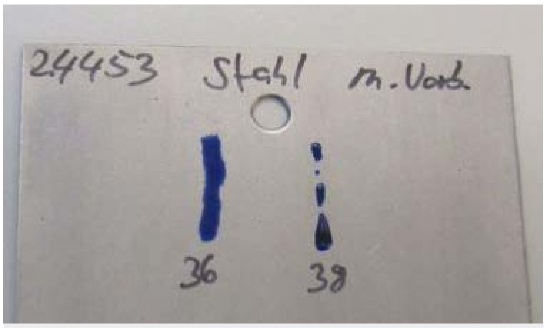


Figure 28: Determination of degreasing by means of test ink

6.2 Mechanical pre-treatment

The surface is roughened during mechanical pre-treatment. In order to achieve the best possible bond between surface and coating, the roughness is essential. In contrast to round blasting agent, a better roughness can be achieved with shot blasting agent. The RZ value should be 25-40 % of the planned coating thickness so that the coating can achieve good adhesion and completely cover the blasted structure.

Figure 29: Angular component blasted with corundum

7. Layer thickness

In order to achieve the necessary corrosion protection, the minimum layer thicknesses (see technical data sheet) must be observed. Since every organic coating has a certain water absorption and permeability, compliance with the minimum coating thickness is an important parameter that must be strictly adhered to within strict limits. Usually, a primer and/or a duplex process (galvanizing and coating) is necessary for high corrosion protection requirements.

Figure 30: Corrosion damage due to insufficient coating thickness

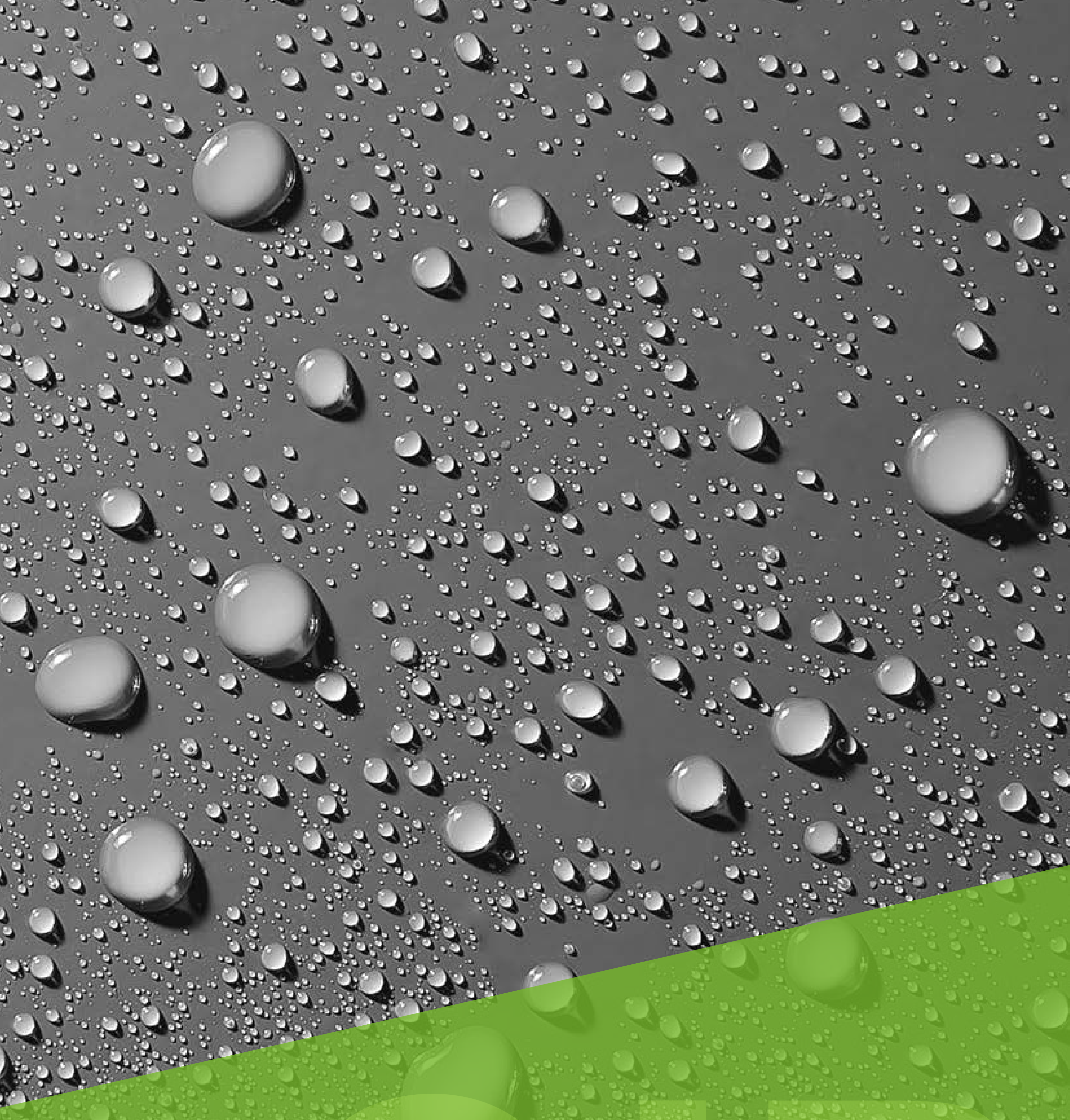
The effective coating thickness can only be ensured if the cut, the weld seams and the joints are correctly machined in the manufacturing process of the workpiece and all surfaces can be reached by the coating material. Deburring and descaling are the responsibility of the manufacturing process and must be taken into account during production. Surface technology deals with the tasks of degreasing, cleaning, conversion layer formation and application of the coating material. (Separation between surface technology and production technology)

The choice of coating material can also influence the formation of the coating layer. High-gloss coatings tend to have a higher edge alignment than finely structured coatings. Via viscosity and the temperature profile in the oven, the paint manufacturer can develop special formulations which make a more uniform coating distribution possible. In the case of blasted surfaces, the measuring device must be calibrated to the blasted substrate. If this is not done, the measurement results will not be correct because the roughness of the material is not taken into account. This can lead to insufficient layer thicknesses being measured on blasted substrates. By rounding off the edges on both sides, a uniform coating thickness can be achieved on edges, holes and cut-outs.

8. Conclusion

When observing the five most important criteria - construction, avoidance of oxide and scale layers, edge radius, suitable pre-treatment process, coating thickness - can the corrosion protection on the coated finished part be improved by a factor up to ten.

With the kind support of:
Markus Lindörfer (**www.blech-entgratung.de**) und
Matthias Bader (**www.bader-pulver.de**)



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