Technical Bulletin

Chemical metal (surface) treatment versus mechanical treatment

The latest developments that are environmentally friendly and just as fast!

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Different mechanical method options are available to carry out pretreatment of steel. These methods are, generally, effective and easy to carry out (provided that the correct equipment is available). A chemical surface treatment can be an alternative but, initially, leads to a certain response from people: Chemicals? But that is not environmentally friendly, it is dangerous, right? I will also have to deal with a waste stream that has to be processed!" This Technical Bulletin provides background information on this preconceived idea.

Distinction in material types

If we wish to make a distinction between the different chemical metal surface treatment methods, the easiest option is to make a subdivision based on the two different alloys that we can find: low-alloy steels such as carbon steel and alloys such as aluminium and stainless steel.
The most significant difference is that low-alloy steel will react instantly under the effect of air (mixture of water and oxygen). In fact, the molecules on the surface wish to return to the state of the lowest possible energy. In the case of carbon steel, the iron molecules that have been compressed into a specific form under the effect of heat and pressure wish to return to the forms of iron ore, the original state.
A reaction also takes place with regard to high-alloy steel on the surface between, for example, chromium and nickel molecules in the case of stainless steel. This will, however, lead to a passive (chromium) oxide film. This film forms a living protective layer. This film, however, can be sensitive to corrosive effects. These will be different depending on the alloys but, generally, base particles and chlorides represent a hazard for the passive film in nearly all cases. If these particles are not removed in time through cleaning, the passive film on the surface will be damaged and the particles may penetrate to the underlying layer that will lead to corrosion.

Result of a chemical metal surface treatment – low-alloy steel

Now that we have made this distinction, we can examine which chemical surface treatment is possible and what consequences this has. A coating or another form of permanent conservation will always be required in the case of low-alloy steel types. Often, pretreatment focuses on removing contamination and the conservation layer must be applied as quickly as possible. Mechanically, we consider sand-blasting, sanding, polishing, etc.

Immersion of carbon steel pipes in a phosphate bath; rust is removed and a phosphate layer remains

Chemically, we consider:

1) Dissolving the scale and/or rust
2) Converting rust

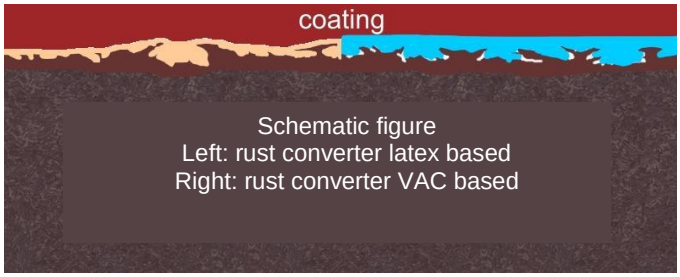
Should we consider **option 1,** it emerges that steel/iron-based alloys can easily dissolve in acid. The advantages of this method are obvious: it requires little or nearly no manual effort, it can take place very quickly, it is thorough and provides a uniform result even at places that are difficult to reach with mechanical tools. In the case of carbon steel alloys (alloys that are found the most), the choice is often hydrochloric acid or phosphoric acid. Citric acid or oxalic acid is also eligible. The great advantage of phosphoric acid is that a phosphate layer is already created on the surface (with the correct dose; ≤ 5%). This layer provides temporary conservation to the surface. The disadvantage of the low dose is that the temperature of the immersion bath must be relatively high (> 50°C) for an acceptable fast effect. Good inhibitors must be added to the bath when other acids are used to ensure that the acid cannot have an effect that is too aggressive on the material and also to prevent that the material starts to corrode immediately after treatment. A good detergent must also be available in such a bath to reduce the surface tension so that a uniform effect can be guaranteed.
A disadvantage of this method is, of course, that we need to invest in a bath, liquid, heating and, last but not least, the required permits. The hazard of such a bath is not, in fact, that great. The discharge standards for iron are also

unlimited or very high at most authorities. The waste stream must, however, be neutralised in all cases. By adding a high alkaline liquid (for example, calcium chloride) and ensuring the pH value becomes ≥ 7.5, most metals will, however, precipitate. The waste stream can then be guided over an oil/grease separator and will then meet the discharge standard in most cases.
A submerging treatment does not, of course, always have to be performed using your own submerging trays or baths. Various companies based in the Benelux have large submersion trays where structures can be submerged and conserved.

Option 2 describes a method that does, indeed, provide a rougher surface but that does have a very fast and simple effect. Investing in immersion facilities is, therefore, not required in principle when a brush and spay equipment is used. Rust conversion has been taking place for dozens of years.

Hammerite is a well-known example of a rust converter in combination with a permanent conservation (coat). We would like to thank Hammerite® for providing the photo

The “Hammerite®” brand has even built up its reputation on this with consumers. The principle of a rust converter is based on a reaction between the already corroding material and tannin. The reaction that is created can occur very quickly. In less than 2 hours, an inert layer may already have been created that will stay in this condition for at least 24 hours (under normal and, therefore, non-corrosive conditions). Ultimately, a permanent conservation must be applied as is the case with all low-alloy steel types. An important misconception when applying a rust converter is the layer thickness. Although the layer thickness is very important with regard to a coating for durability, this is completely irrelevant in relation to a rust converter. We still, however, see rust converters being used in practice that are based on, for example, vinyl acrylic copolymers (VACs). These products can be easily recognised by a high viscosity (viscous to very viscous) and often contain a lot of solvents. A significant disadvantage of this type of carrier for tannin is that the active substance penetrates with difficulty into small cavities of the surface. The result is that a corrosion risk will still be present from the deeper situated cavities where the tannin has not been able to react with the “rust”. Also see



the schematic figure. Other disadvantages of such a carrier are the long drying time and the flammability/fumes that are created when drying. An optical advantage is the smoother surface that is produced.

It is technically better to use a rust converter with a very low viscosity (watery) so that the tannin is given the opportunity to penetrate as deeply as possible into the surface. This will guarantee that the surface becomes completely inert (another term for passive). When a natural latex is used as the carrier, the drying time is very short and the product very safe, fast-drying and fire resistant. It applies to all rust converters that loose rust scales must be removed using a wire brush or sticking knife. Tests have shown that treating with a latex-based rust converter in combination with applying a finish coat, provides the most durable protection against corrosion, next to fully blasting and coating.

Rusty carbon steel pipe immerged in Rust Converter Super. The inert result was obtained in 2 hours (ambient temperature of 20°C and atmospheric humidity of 85%)

Result of chemical metal surface treatment – high-alloy steel

While a "rusting" layer or scale of the surface must be dissolved with regard to low-alloy steel types, chemical pretreatment is, in fact, lightly etching the material with regard to high-alloy steel types such as aluminium and stainless steel. By doing this in a controlled manner and lightly, a surface roughness is created that will ensure that a coating (in the case of aluminium) will adhere a lot better. Mechanical alternatives are glass, ceramic and grit (pearl) blasting. The disadvantage of these treatments are the expensive installations, dependence of the blaster with regard to variation in surface roughness and the purity of the grit or pearls. If one or a few of these factors are not OK, good adhesion of the coating cannot be guaranteed. Chemical surface treatment also takes place in combination with acids in this case. This will often be a combination of phosphoric acid and hydrofluoric acid in the case of aluminium. In addition to these acids, detergents and possibly inhibitors are also added. The liquid can be applied through spraying or submerging. The effect of these etching resources can be very quick. Somewhat dependent on the exact alloy and ambient temperature, the time before an effect is seen will range between 15 and 45 minutes.

Pretreatment of aluminium for welding

Pretreatment of aluminium can also strongly affect the welding quality and this is especially true when aluminium oxides have already formed on the surface (white dots or haze). Mechanically roughening the seam to be welded provides the best result. An aluminium or stainless steel brush must, however, be used within this context. Chemical pretreatment using phosphoric acid and hydrofluoric acid is recommended when brushing is not possible. Rinsing and drying must, however, of course, take place before the weld can be made.

Conclusion:

Chemical surface treatment of carbon steel can be performed fast and relatively environmentally friendly. The most important advantage is a uniform and high-quality effect and even conservation in one step. The disadvantage is that submersion in a (heated) bath provides the best result in most cases and this is not an option for all sizes of structures. There are more issues to consider with regard to the environment in relation to the pretreatment of high-alloy steel types and aluminium when chemically pretreating. However, as long as we do not discharge into the sewer (and, therefore, properly discharge rinsing water and bath liquid), the measures with regard to permits can still be kept track of.

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Seam smoothed using a stainless steel brush

Acid-treated seam

Untreated seam