THE CORROSION EXPERTS

THE CHALLENGE OF HYDROGEN EMBRITTLEMENT

Hydrogen-induced stress corrosion is a frequent cause of sudden failure of machine and agricultural equipment systems.

Although red rust on agricultural machines and appliances impairs the high-quality appearance of what are often very expensive investments, it does not generally have any detrimental effect at first on how well large-format components work. Signs of rust, in fact, enable corrosion to be controlled, as they mean that the gradual process gets noticed early on. There is, however, another phenomenon that appears to come ‚right out of the blue': hydrogen-induced stress corrosion. Especially on components subjected to high levels of stress, it leads to sudden failure. Construction parts, including high-strength fasteners, break without a moment's notice. For machines that need to be reliably in non-stop use during periods of soil cultivation, manure spreading or harvesting this is an absolute disaster.

Interplay of different causes

This danger relates especially to high-strength steels with tensile strengths of > 1,000 N/mm² and is caused by hydrogen atoms that diffuse into the steel. This is made possible by, for example, structural flaws, inclusions, impurities or mechanical tensions during steel production. Further influencing factors then arise during the manufacturing of components made of steel as a result of measures such as shaping, hardening or heat treatment. The third factor is represented by the part's coating. During pickling and electrochemical cleaning processes and during electrochemical coating of steel parts, atomic hydrogen is always created in the process bath and it is possible for this to diffuse into the surface of the steel. In every instance it is the critical interaction of different influencing factors that ultimately leads to the failure of a component, without the user being able to notice any prior damage.

A creeping process

Inside the steel, the atomic hydrogen moves to zones with high levels of tensile stress, such as external and internal indents or ridges. It accumulates there and consequently weakens the metal compound until a microscopic crack occurs. While this reduces the stress on this zone, new concentrations of tension get created at the crack's tip, which in turn again attract atomic hydrogen, become weakened and crack. As a final consequence the remaining cross-section is no longer able to bear the external tensile load and breaks as a forced rupture.

DIN 50969-1 describes how the factors that influence hydrogen-induced stress corrosion can be reduced through the structural design of the component, through measures relating to the materials and production methods used and through lowering the levels of internal tensile stress. Attempts can also be made at the coating stage to minimise hydrogen absorption through appropriate process management –

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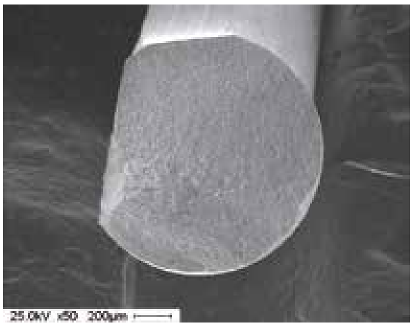
for example, by not using pickling at the pre-treatment stage, but instead blasting or degreasing by alkaline means. It is also possible to have the hydrogen effused again by tempering. This, however, depends on the structure of the coating and is time-consuming and thus costly.

Quality assurance from zinc flakes

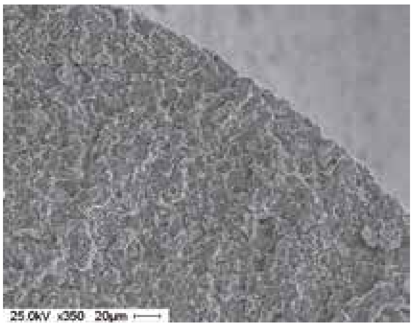
The best solution is therefore to use a coating system involving a process that produces no hydrogen at all: non-electrolytically applied zinc flake coating is thus a good choice for the challenge of protecting a high-strength component from corrosion. A coating made of zinc flakes is a ‚paint' made up of lots of small flakes with the primary purpose of providing protection from corrosion for components of various kinds. Through the sacrificial effect of the less noble zinc it provides active protection from environmental influences: this form of corrosion protection is called cathodic protection. Zinc flake coatings generally contain a combination of zinc and aluminium flakes (as per DIN EN ISO 10683 or DIN EN 13858), which are fused together by an inorganic matrix. The coating gets cured at low temperatures, taking place from as low as 200° Celsius.
Depending on component, a variety of different forms of application are appropriate: for example, dip-spinning for screws and spraying for larger components. The failure of construction parts or fastening systems exposed to high levels of stress on agricultural machines or appliances can lead to damage of a magnitude in value terms that bears no comparison to the cost of the coating system used. Using zinc flake systems makes it possible to provide such machines with high-performance cathodic corrosion protection, without the danger of any process-induced hydrogen embrittlement.

We would be happy
to discuss these topics with you:

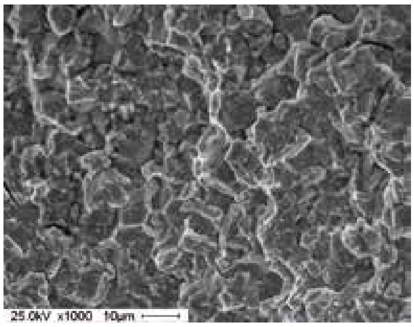
- Chromium(vi) ban by 2017
- Hydrogen embrittlement
- Chemical and fertiliser resistance
- Replacement of stainless steel
- Functionality: retaining value



Overview of a spring's fractured surface with a curved forced rupture originating between the inside of the coil and its side surface.



Rupture's starting area, curved forced rupture originating from the surface



Ruptured surface near to the start of the rupture: inter-crystal-line forced rupture showing characteristics of hydrogen embrittlement

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