

Stress Corrosion Cracking: Causes and Solutions

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Why normally ductile and strong alloys should fail in an essentially brittle manner when exposed to certain environments at relatively low stresses? This question has intrigued many people for more than a century. Stress corrosion cracking (SCC) is definitely one of the possible common causes. SCC is not unfamiliar to materials scientists or structural engineers; however, strangely many of them have wrong conception about the phenomenon.

It is important to point out that stress corrosion occurs in so-called “corrosive environments” but the environments do not have to be really chemically “corrosive”. In most cases, products of chemical corrosion cannot be found on SCC fracture surfaces.

Stress certainly plays a role in the SCC process, but it should be pointed out that not all types of stresses facilitate stress corrosion. Compressive stresses may even be deliberately introduced to the surfaces by shot peening to combat SCC. The stresses imposed upon the structures during service seldom cause SCC because the applied loads are usually limited by a generous factor of safety and are well below the yield points. In fact, SCC is often caused by residual stresses generated during forging, assembly, or welding. SCC is sometimes considered to be welding’s no. 1 nemesis.

The short talk will cover basic concepts of SCC, common causes of SCC, methods for testing SCC susceptibility of welded joints, and SCC control measures. Good knowledge of SCC may help petrochemical industry save lots of money. There is a tendency for many companies to replace austenitic stainless steels with much more expensive titanium alloys in applications where SCC might be problematic, but actually one of the duplex stainless steels can be an adequate and much cheaper replacement. The talk pays special attention to SCC in welding of stainless steels but SCC of aluminium alloys and other materials is also discussed.

Why ductile and strong alloys should fail in brittle manner when exposed to certain environments at relatively low stresses?

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- Stress corrosion cracking (SCC) is definitely one of the possible common causes. Other causes?
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Causes for Stress Corrosion Cracking?

- (1) Stress
- (2) Corrosive environments
- (3) Susceptible microstructures

Stress?

- Must be sustained surface tensile stress. Compressive stress helps to avoid SCC.
- NOT necessarily applied stress.
- Common sources of tensile stress:
 - (1) assembly stresses;
 - (2) residual stresses due to forming, heat treatment, cladding, and welding;
 - (3) concentration of stress at the root of pre-existing cracks or notches

Magnitude of tensile stress is important. There exists a threshold stress value

Corrosive environments?

SCC \neq Corrosion

SCC occurs in so-called "corrosive environments" but the environments do not have to be really chemically "corrosive". In most cases, products of chemical corrosion cannot be found on SCC fracture surfaces.

How Can SCC Occur?

- Continuous destruction of protective film under combined effect of tensile stress and “corrosive” environment
- H induced cracking

Recommendations

Steel Selection

For use in environments likely to cause SCC, steels inherently more resistant to SCC in the particular environments should be used.

Fabrication

- Careful fit-up in welding: to avoid locked-in stresses
- Stress relieving after welding wherever practical
- Avoid sharp notches, crevices, and rough finishes
- Avoid galvanic couples between dissimilar metals
- Limit hardness (e.g., below HRC30)

Surface Treatment

Shot peening or surface burnishing produces compressive stresses, which are helpful in preventing SCC.

Note: Use corrosion resistant steel shot or glass beads on steels to avoid anodic corrosion of the surface or remove shot residue from use of steel shot where deleterious.

Design Stresses

The lower, the better.

Generally, limit stresses to below 50% yield stress.

Protective Coating

- Organic coatings are generally helpful in minimising stress corrosion if they are adherent and nonporous.
- Metallic coatings may be used but the possibility of accelerating SCC should not be overlooked (e.g., if the coating is cathodic to the base metal or causes hydrogen embrittlement)