Technical Bulletin

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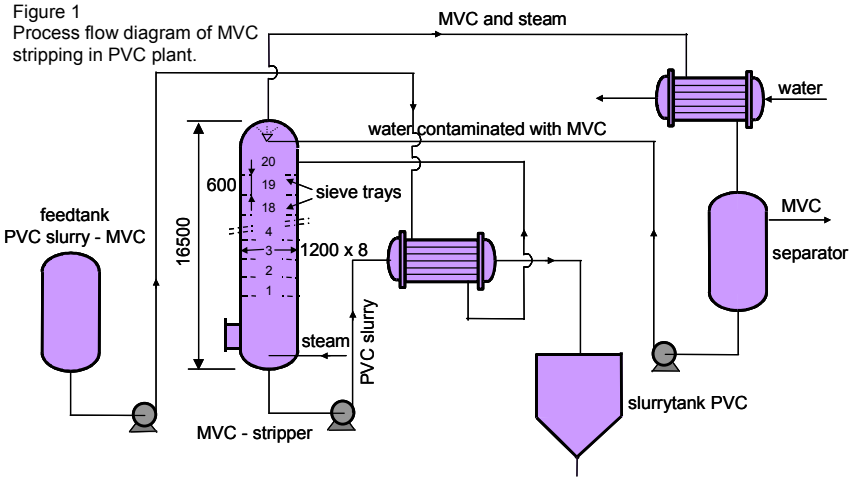
STRESS CORROSION CRACKING IN DUPLEX STAINLESS STEEL MVC STRIPPERS IN A PVC PLANT

Case 1, continuation on Technical Bulletin 2005/11

Introduction

Stripper columns in type AISI 316L handling a vinyl chloride slurry with a pH of 2.8 to 3.5 and 20 to 50 ppm chlorides developed stress corrosion cracking after only a half year on stream. A process flow diagram of MVC stripping in PVC plant is shown in Figure 1. The service temperature is about 105 deg. C and the pressure 1.05 bar. In late 1986, after eight years in service, the four strippers were replaced by similar units in type X2CrNiMoN22-5-3 duplex stainless steel.
A year later, in a similar plant, four strippers in X2CrNiMoCuN25-7-3 were installed.

Figure 1
Process flow diagram of MVC stripping in PVC plant.



Occurrence of SCC in duplex stainless steel MVC strippers

Inspections after eight to twelve months revealed stress corrosion cracking in all strippers. It was observed that the welds and zones next to the welds were covered with porous oxide layers due to welding without sufficient protective inert gas. Despite strict recommendations in the specification these heat tints were not removed. The incidence of cracks in the 22% Cr grade is greater than in the 25% Cr grade.

Inspections after another year showed that crack formation had practically come to a halt and that there had been only little propagation of existing cracks. The cracks originate from the welds and propagate into the plate material, perpendicularly to the weld, over a length of maximum 20 mm (Photo 1). Microscopic examination revealed that the branched cracks progress mainly through the austenite phase of the plate material (Photo 2).
On the photos, the austenite phase is darkish as a result of etching in accordance with LB1 (Lichtenegger and Bloech). In weld deposit material, too, cracking propagates preferably through the austenite phase albeit less markedly than in plate material (Photo 3).

Photo 1
Cracking in X2CrNiMoN22-5-3 MVC stripping columns

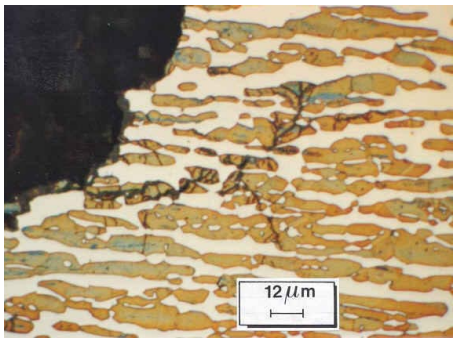


Photo 2
SCC in austenite phase of X2CrNiMoN22-5-3 (etching LBI)

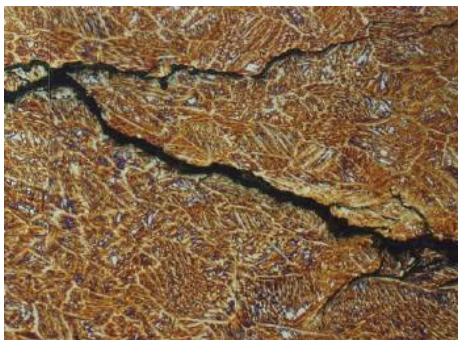
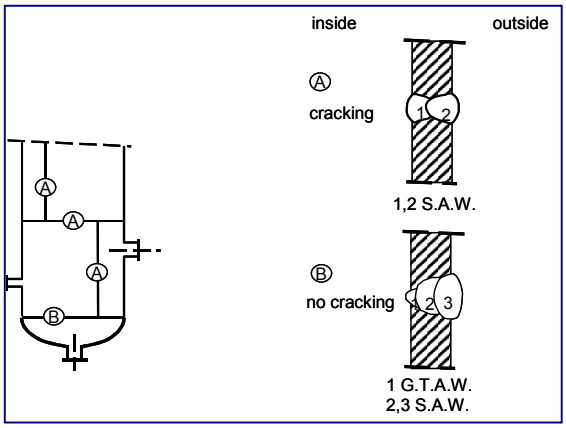


Photo 3
SCC in weld deposit material of stripping columns (etching LBI)



It is remarkable that cracks are located at the inside surface in and adjacent to the double sized SAW welds. The closing seam of the stripper was welded from the outside with a GTAW root and SAW filler layers (Figure 2). After two years on stream, this weld did not exhibit any cracks.
The double sized GTAW welds of the nozzles, too, show cracks emanating from the inside surface. We should add that the seam welds had not been pickled. We believe this omission promotes selective adsorption of chlorides in the porous oxide skin resulting from welding operations. The chlorides so adsorbed increase the risk of stress corrosion cracking.
After some 4 years on-stream in the weld indicated B also cracking was observed.

Figure 2
Welding process and welding sequence in MVC stripping columns.

Constant Extension Rate Testing (CERT)

A comparative evaluation was made of the susceptibility to SCC of duplex steels and Type AISI 316 steel in a calcium chloride environment as a function of pH. These tests were carried out by means of computer-controlled tensile testing machines.
It is remarkable that in the PVC slurry out of the bottom of the stripper with 50 ppm and pH of 2.8 it appeared not to be possible to find indications of SCC. Even in (neutral) calcium chloride solutions up to 25% the relative elongation fails to give any clear indication of SCC. At 40% calcium chloride, a higher susceptibility to SCC can be observed at lower pH values.
Figure 3 shows the relative elongations at fracture of duplexes and Type AISI 316L in a 40% calcium chloride solution in relation to the elongation in glycerine, as a function of the pH value.
Figure 4 shows a stress strain curves determined by constant extension rate test (CERT); temperature: 123°C; e = 10^{-6} sec^{-1}.

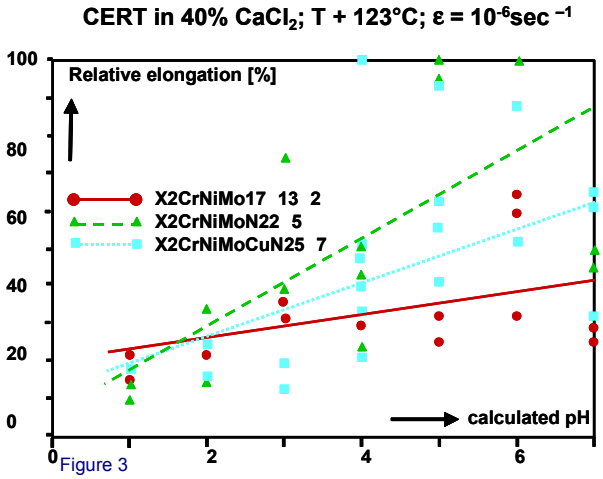


Figure 3
SCC test results by means of CERT in 40% $CaCl_2$; temperature: 123 °C; e = 10^{-6} sec^{-1}.

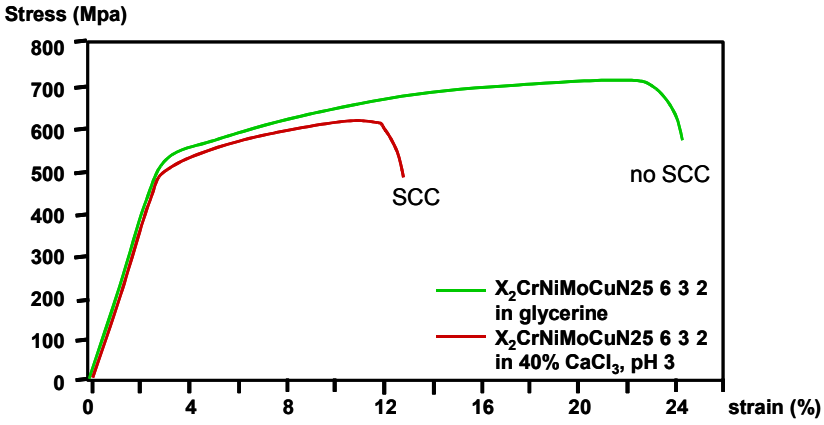


Figure 4
Stress strain curves determined by constant extension rate test (CERT).
Temperature: 123 °C; e = 10^{-6} sec^{-1}.

Out of these CERT results it was concluded that the micro environment in the porous heat tints must be much more aggressive than the bulk solution due to selective adsorption of chlorides and drop of pH. Due to the presence of heat tints the initiation of SCC has been accelerated.

Conclusions

- Duplexes may be used in numerous applications to replace common austenitic stainless steels because of their superior resistance to SCC.
- Resistance to chloride SCC at low pH values (about 3) is hardly any better than that of, say, X2CrNiMo17-13-2.
- Due to presence of heat tints the initiation of SCC has been accelerated. To avoid or minimize the risk of SCC heat tints should be removed.

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