Resistance to stress corrosion cracking of a new high strength stainless steel wire material

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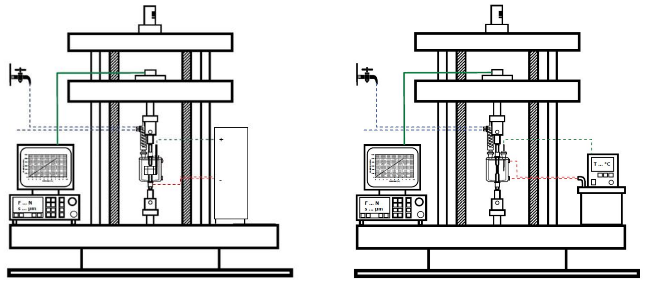
INTRODUCTION

High strength steels have a very strong tendency to hydrogen embrittlement, while austenitic stainless steels often no longer meet modern strength requirements in the oil & gas industry. This article describes the resistance to stress corrosion cracking of a new nitrogen alloyed stainless steel with the potential to meet all requirements in terms of strength and corrosion resistance for future applications.

EXPERIMENTAL

The results are obtained from slow strain rate tests (SSRTs) of electrochemically hydrogen charged samples and SSRTs in different chloride solutions at elevated temperatures.



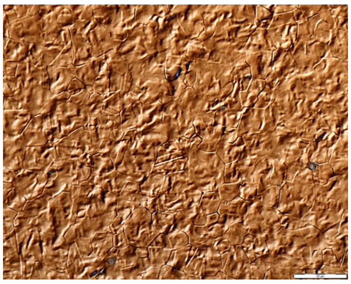
[1]

Hydrogen induced stress corrosion cracking (HISCC) Strain rate 2 * 10^{-6} s^{-1}	Chloride induced stress corrosion cracking (Cl⁻SCC) Strain rate 2 * 10^{-6} s^{-1}
Air, RT	Glycerin, 80 °C
3.5 % NaCl + 1 g/L CH_4N_2S, 1 mA/cm², RT	Glycerin, 120 °C
	5 % NaCl, pH 3.5, 80 °C
	43 % $CaCl_2$, pH 4.6, 120 °C
	42 % $MgCl_2$, 120 °C

For HISCC as preliminary tests, the hydrogen contents of charged samples (30 x 6 x 6 mm) were measured by means of carrier gas hot extraction after different loading times in order to adjust a certain hydrogen saturation value [2,3]. Tensile specimens with a diameter of 3 mm and a gauge length of 25 mm were pre-charged for 3 days and then SSRT were done with continued hydrogen charging.

Material

Material was a high nitrogen steel with a fully austenitic microstructure. The approximate grain size is 15 µm in the hot rolled condition. No precipitations are visible in the cross section at a magnification of 1000 x.

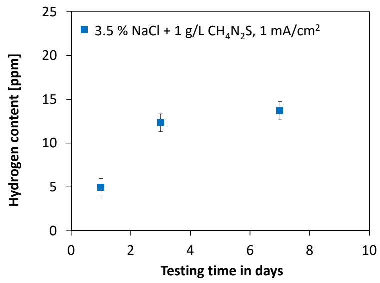


Chemical composition [wt. %]							PREN [1]	CPT [2]	UTS
C	*Cr*	*Ni*	*Mo*	*Mn*	*N*	*H* [3]		[°C]	[MPa]
< 0.05	26 – 28	14 – 16	3 – 4	5 – 6	0.65 - 0.75	0.00376	> 48	> 90	1050

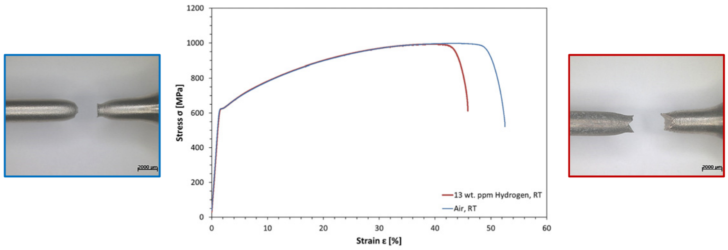
[1]PREN = % Cr + 3.3 % Mo + 16 % N
[2]According to ASTM G48 Method C
[3]determined by carrier gas hot extraction

RESULTS

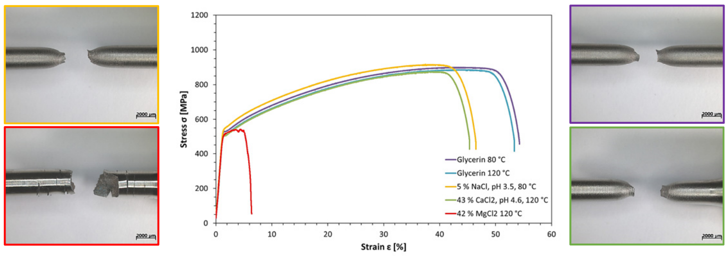
Hydrogen content after pre-charging



Resistance to HISCC

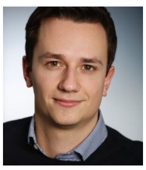


Resistance to Cl⁻SCC



CONCLUSIONS

- Cathodic hydrogen charging in neutral solutions with the addition of thiourea leads to a hydrogen value of 13 wt. ppm.
- Good resistance against HISCC due to a stable austenitic microstructure.
- Excellent resistance in 43 % $CaCl_2$ at 120 °C and in 5 % NaCl buffered pH 3.5 solution at 80 °C.
- Visible Cl⁻SCC in 42 % $MgCl_2$ and some HISCC at 13 wt. ppm hydrogen.



Contact

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Literature

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[3] D. Pérez Escobar, C. Miñambres, L. Duprez, K. Verbeken, M. Verhaege, "Internal and surface damage of multiphase steels and pure iron after electrochemical hydrogen charging," *Corrosion Science* 53, 10 (2011): p. 3166–3176.