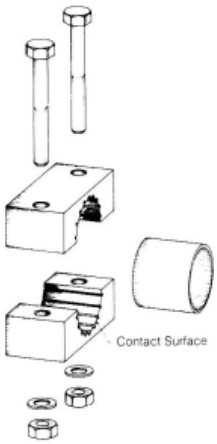


Selection of High-alloyed Steels for Seawater-cooled Condensers

L.M. Butter, A.H.M. Keller, H.B.J. Klein Avink, W.M.M. Huijbregts
ACOM (Avesta Corrosion Management) No 3-4, pg 12-14, 1986,
Poster presentation at the NCC/SMOZ conference

Introduction

High-alloyed steels can be applied in seawater-cooled condensers, if they have great resistance to pitting and crevice corrosion. To obtain appropriate selection criteria the results of electrochemical measurements have been compared with those of exposure tests in artificial and natural seawater. A great number of steels have been tested. See the table 1, in which the steels and the results are summarized. For some steels more heats were tested.

Present address.

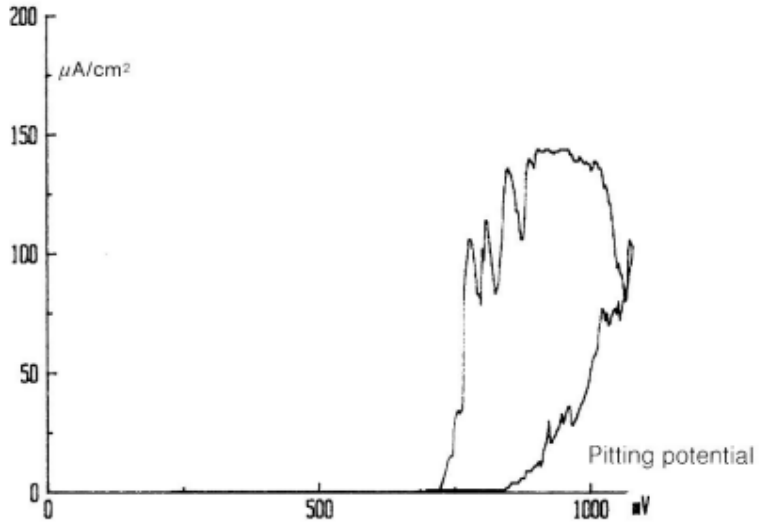
Wally Huijbregts, Utrechtseweg 114, 6871 DV Renkum, The Netherlands

Tel. +31 (0)317 350713, E-mail: whuijbregts@xs4all.nl, Web: www.hbscc.nl

Electrochemical Characterization

Pitting Corrosion

The resistance to pitting corrosion has been deter-mined by means of polarization curves, measured in artificial seawater at a low potential scanning rate (3 mV/min).



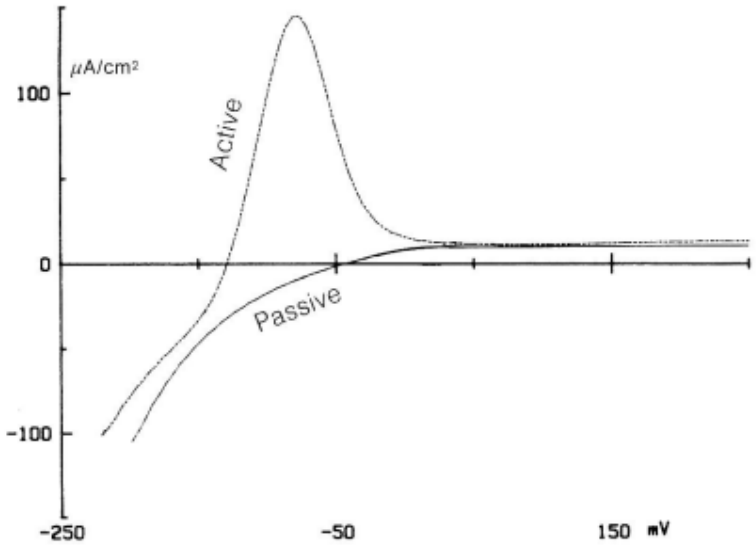
On the basis of their pitting potential values the steels have been divided in three categories:

- pitting potential lower than 900 mV
+ pitting potential higher than 900 mV, but lower than 1200 m V
++ pitting potential higher than 1200 mV

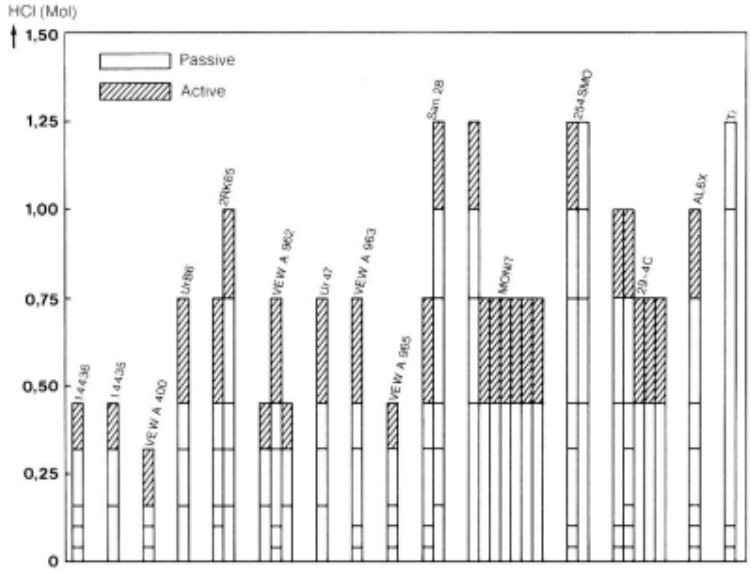
The pitting potentials of the AL6X, 29-4C and 254 SMO steels are high (>1200 mV). Most heats of Monit 2502 also have high pitting potentials, but some show values in between 900 and 1200 mV.

Crevice Corrosion

Condenser tubes can be blocked by spongy rubber balls, pocks, eels, etc. This may result in crevice formation inside the tube. Hydrolysis of corrosion products will result in a pH-decrease in the crevice. Even high-alloyed steels can lose their passivity in this acid environment. The active-passive behavior of the steels has been determined by means of polarization curves, measured in acidified 6 % NaCl-solutions.



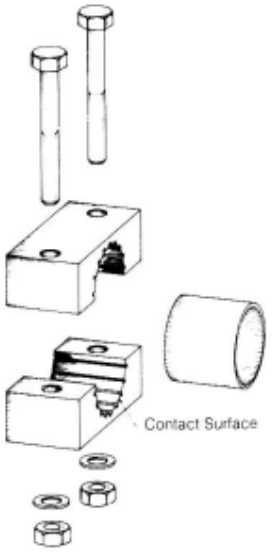
The acid concentrations in which the steel remained passive and became active are shown in the following figure.



Both heats of 254 SMO were passive in very high acid concentrations. One of the heats was still passive even in 1.25 Mol HCl. The materials Sanicro28 and Monit 2502 showed more variations in critical acid concentrations. See also the table on page 14 (All mV-measurements are made against NHA).

Exposure in Seawater

Crevice-type tube samples were exposed in artificial and in natural seawater. In case of a blocked condenser tube, the seawater temperature in the crevices would become equal to that of the condensed steam (40°C). The seawater in our experiments was heated up to this temperature.



Artificial Seawater

The samples from the laboratory exposure tests have been inspected frequently. The larger part of the materials showed corrosion in some degree. Only 254 SMO and AL6X were not corrosded, although they had been exposed during 75 weeks. See table 1 for results.

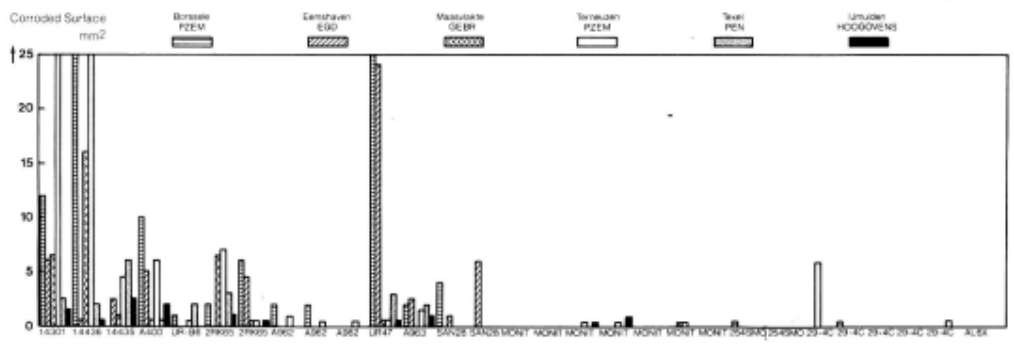
Natural Seawater

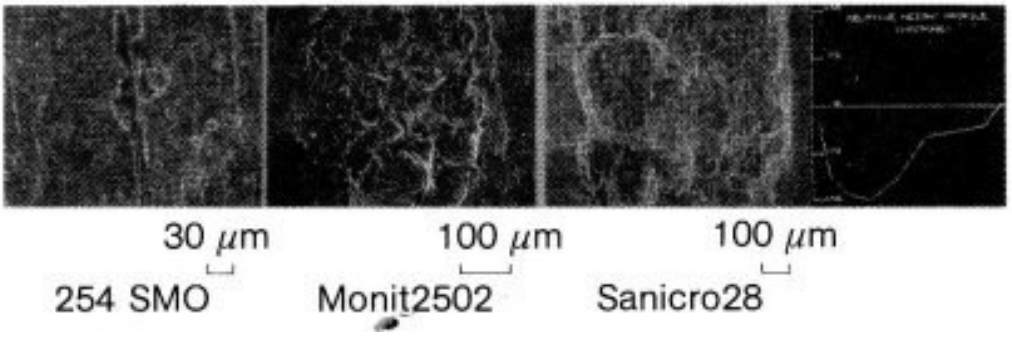
For the exposure in natural seawater 6 sites were chosen along the Dutch coast.

The samples were examined for corrosion after 1.5 years of exposure. The corroded surface areas were measured and plotted in the diagram at the bottom of this page.

Judging from the corroded area of the samples the corrosivity of the water on the 6 sites decreased as follows:
Terneuzen - Borssele -> Eemshaven -> Maasvlakte -> Texel - IJmuiden

The differences were rather small. On the IJmuiden site the harbour water was used.
Samples with only very small corroded areas were examined in the Scanning Electron Microscope (SEM). The corroded spots had an etched surface. Only a small defect on the 254 SMO material had no etched surface. It rather seemed to be mechanical damage. The depth profiles on the corroded spots were measured by means of the SEM technique.


Corroded Surface
mm2
Borssele
PZEM
Eemshaven
EGD
Maasvlakte
GEBR
Terneuzen
PZEM
Texel
PEN
Umuiden
HOOGOVENS
25
20
15
10
5
0


30 μm
100 μm
100 μm
254 SMO
Monit2502
Sanicro28

DIN Code	Trade Name	Heat	Electro-chemistry 1	Electro-chemistry 2	Exposure in Seawater 3	Exposure in Seawater 4	Exposure in Seawater 5
		a			–	– –	
		a	–	–	–	– –	
		a	–		–	– –	
		a		–	–	– –	
x2NiCrMoCu25 20 5	UR. B6	a		–		–	
	2RK65	a	–	–	–	– –	
		b	+	+	–	– –	
	A962	a		–		–	
		b		–		–	
		c		–		–	
				–	–	-	
				–	–		
			–	–	–		
			+	+ +	+		
x2CrNiMo25 4 4	Monit	a	+ +	+ +	+	+	
	2502	b	+ +	–	–	+	
		c	+ +	–	+	–	50
		d	+ +	–	+	–	30
		e	+	–	–	+	
		f	+	–		–	50
		g	+ +	–		+	
x2CrNiMoCu20 18 6	254 SMO	a	+ +	+ +	+	–	40
		b	+ +	+ +	+	+	
x2CrMo29 4	29-4C	a	+ +	+	+	–	25
		b	+ +	+	+	–	
		c	+ +	–	+	+	
		d	+ +	–	+	+	
		e	+ +	–	–	–	50
x2NiCrMo24 20 6	AL6X	a	+ +	+	+	+	
Titanium		a	+ +	+ +		+	

1 Pitting potential <900 mV: -; >900 mV: +; >1200 mV: ++
2 Active behavior in HCl Mol: <0.75: -; ?0.75: +; >1.0: + +
3 Exposure in artificial seawater after 75 weeks corrosion = -; no corrosion = +
Exposure in Natural Seawater
4 Corroded surface area: 0 mm2: +; 0-10 mm2: -; >10 mm2: -
5 Depth of corrosion spots (micron)

Conclusions

The two heats of the 254 SMO steel have the greatest corrosion resistance.

The AL6X steel also has great corrosion resistance. Only one heat of this material was tested. The 254 SMO steel is considered a good alternative material for Titanium condenser tubes.

The Sanicro28, Monit2502 and 29-4C steels showed rather high variations in corrosion resistance. Pre-selection of the material by means of laboratory tests, such as electrochemical measurements, is necessary.

Electrochemical measurement of pitting potential and critical acid concentration for passive behavior is considered to be a good selection test. For the application of stainless steel in seawater-cooled condensers a pitting potential of at least 1200 mV and a critical acid concentration for passive behavior of 1 Molar are proposed as selection criteria.