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STRESS CORROSION CRACKING OF FE-CR-NI ALLOYS
IN CAUSTIC ENVIRONMENTS

R. W. Staehle
Department of Metallurgical Engineering

April 16, 1969 - July 15, 1969

U. S. Atomic Energy Commission
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On STRESS CORROSION CRACKING OF Fe-Cr-Ni ALLOYS IN
CAUSTIC ENVIRONMENTS

For the period April 16, 1969 - July 15, 1969

Submitted by Roger W. Staehle

Department of Metallurgical Engineering

Date August 22, 1969

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Fig

1.0 ABSTRACT

Work is underway to construct equipment for electrochemical and stress corrosion studies.

Prototype cells have been constructed and preliminary work is underway. Early stress corrosion experiments will be conducted at boiling temperatures and will evaluate general patterns as affected by alloy composition and electrochemical potential. Later experiments will consider the effects of temperature, stress, and solution composition. Polarization experiments will consider initially the general pattern of active and passive regimes as affected by alloy.

2.0 SUMMARY AND CONCLUSIONS

1. A prototype cell for stress corrosion tests in boiling NaOH solutions has been constructed and preliminary work shows they are satisfactory.

2. A prototype cell for polarization measurements in caustic solutions has been constructed.

3.0 INTRODUCTION

The purpose of this program is to evaluate systematically the susceptibility of Fe-Cr-Ni alloys to stress corrosion cracking in caustic (high pH) environments. The work will consist of (1) a broad phenomenological study to find the general pattern of cracking as a function of important engineering variables and (2) an intensive mechanistic study to provide a basis for predicting the incidence of cracking as a function of important engineering variables.

4.0 STRESS CORROSION CRACKING STUDIES

(D. V. Subrahmanyam)

4.1 Introduction

This program is aimed at systematically evaluating the cracking behavior of a broad range of high purity and commercial alloys using a constant environment. The alloys being used are those already prepared for the OSU program on chloride cracking.

Boiling sodium hydroxide solutions are being used for this initial work since temperature is not a major variable. In the near future, more refined electrochemical vessels involving precise temperature control will be designed. An all-teflon cell, which is capable of withstanding any pH up to 200°C, has been built. Simultaneously, attempts are underway to devise a reliable mercury-mercuric oxide reference electrode.

4.2 Experimental

Extruded teflon tubing and rods were utilized for fabricating the cell. Rods of 1" x 2 1/4" diameter were screwed into the top and bottom of the 3" o.d. x 2" i.d. x 6" height tubing. These rods will be referred to here as top and bottom caps. The top cap has five 10/30 type tapering inlets, the central inlet being utilized for the specimen. Detailed sketches to dimensions of top cap, cell, bottom cap including teflon insert and final screwing arrangement are shown in Figs. 1 to 3.

*Four more 10/30 type tapering inlets are provided symmetrical with respect to the central one.

SKETCH:

Fig. 1 - Design for the Top Cap of the Cell

SKETCH:

Fig. 2 - Design for the Main Body of the Cell (Cylindrical)

S = Teflon Screw; I = Teflon Insert,
design of which is shown separately

1/4 inch diameter grooves are provided
on either end of the bottom cap to
tighten it firmly to prevent leaks

TEFLON INSERT:

Fig. 3 - Design for the Bottom Cap of the Cell

The experimental arrangement is shown in Fig. 4. The specimen wire passes through the condenser and the cell. The top end is tied to a nylon cord connected to the load. The bottom end is fixed to a pin vise. When the specimen breaks, the load falls on the microswitch which breaks the circuit and is recorded on an event recorder. The cell is jacketed with glass tubing. This is wrapped with a heating tape and padded with asbestos. The temperature of the solution in the cell is controlled by a powerstat.

Preliminary runs were made with Type 304 stainless steel wires. The specimens were degreased in acetone and mounted in the experimental cell. Fifty per cent sodium hydroxide solution is heated to boiling in a nickel crucible and then introduced into the cell. At this stage the power to the cell is turned on and the load applied. Failure times at two stress levels are shown in Table I. They are quite reproducible. After failure, the wire exposed to sodium hydroxide solution is covered with a black coating.

These preliminary experiments show that the teflon cell can be successfully operated with minimum difficulty.

A set of six of these cells are now being fabricated and separate potential controllers are being purchased for each cell.

TABLE I. SCC in 50% NaOH Solutions*

Run	% Yield (psi)	Load, (lb)	Failure Time, (hr)	Average Failure Time, (hr)
1	90	3.275	134.2	122.6
2	90	3.275	111.0	
1	150	5.460	95.2	96.8
2	150	5.460	98.3	

*Boiling 50% sodium hydroxide solution (temp. 125°C); yield stress 20,600 psi; Material 304 W-H₂ (Composition %—C 0.08, Mn 2.0, Si 1.00, P 0.045, S 0.03, Cr 18.00-20.00, Ni 8.00-12.00 and balance Fe); as received samples were acetone degreased.

Fig. 4 - Experimental Arrangement (not drawn to scale)

5.0 ANODIC KINETICS (K. G. Sheth)

5.1 Introduction

The purpose of this study is to define the regimes of active, passive, and transpassive behavior as a function of important variables including temperature, alloy, and pH. This initial work will be evaluated potentiokinetically. After this program more critical attention will be given to the details of rate processes.

5.2 Experimental

Since contamination is a major problem when glass containers are used, a teflon cell will be used. It is shown in Fig. 5 and is similar in construction to the stress corrosion cell of Fig. 4.

This cell has been constructed and preliminary experimental work is underway.

Fig. 5 - Teflon Cell for Polarization Studies

for

on

Investigator _____ Date _____

Supervisor Roger W. Stachle Date Sept 2 1969
per MS

Executive Director Robert C. Stephenson Date Sept 2 - 1969