

Stress corrosion cracking of brass in ammonia



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Six samples of brass were taken, stamped to induce residual stress, were then exposed ammonia and ammoniacal copper sulphate solutions of different concentrations and composition for a period of 4 days to study the corrosion characteristics of brass in ammonia. Five samples were immersed in the solution and one of the samples was suspended above solution. On visual examination of the samples revealed some corrosion products with stress corrosion cracking on the surface of brass. Microscopy analysis showed that the non-suspended sample which was exposed to ammonia vapour in presence of moisture and oxygen produced high susceptibility to SCC than immersion samples in aqueous ammonia. The cupric ion present in the solution appears as an oxidant that provides a cathodic reaction and induces stress corrosion cracking of brass in ammonia and ammoniacal solutions.

INTRODUCTION:

There are three factors under which stress corrosion cracking is possible a) corrosive medium/environment b) material and c) tensile stress. The corrosive medium to induce stress corrosion cracking depends on the potential, pH and temperature. The stress can be applied stress or residual stress. Stress corrosion cracking can occur in lower stress also hence it is the environment which plays a major role.

Many studies carried out revealed that failures of brass occur mainly in moist conditions where ammonia, water and oxygen are present. Time of cracking depends on the pH of the solution. Dezincification of copper alloy is possible when the zinc content present is sufficient enough.

The aim of this experimental work was to investigate the corrosion behaviour of brass in ammonia.

EXPERIMENTAL PROCEDURE:

Six brass samples and five test solutions were used in the experiment to study the stress-corrosion cracking of brass. The brass samples were labelled A, B, C, D, E, and F following the residual stress given to them by stamping these letters into their surfaces using drill bits. The stamp was done at one end of the samples while the unstressed part served as the control for the experiment. The solutions serving as the test environments were also labelled using the letters 4A, 4B, 4C, 4D, 4E, 4F and their compositions are shown below.

Compositions and colours of test solution observed before immersion

Solution

Label

Composition

Colour observed before

sample immersion

A

Ammonium Sulphate with copper (II): 0. 5M (NH₄)SO₄ + 0. 05M CuSO₄

Pale blue

B

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Ammonia solution with copper (II): 2. 5M NH₄OH + 0. 05M CuSO₄

Dark blue

C

Mattson's solution at pH of 7. 2

Medium blue

D

Modified Mattson's solution containing 5% by volume of 0. 1M NaCl

Medium blue

E

1M Ammonia solution

Colourless

The labelled samples were placed in the glass jar provided and five of the test samples were filled with enough test solution (10mm) to ensure complete immersion of the sample. Excessive alteration of the concentration of the NH₃ solution was avoided by covering the top of the containers. The sixth sample was suspended above solution E (1M NH₃ solution) in a glass jar (4F) by means of a surgical nylon string.

After sufficient exposure of the samples to the solutions for a period of four days, the samples were removed. The samples were visually examined first upon removal from the test solutions. The colours of the test solutions and <https://assignbuster.com/stress-corrosion-cracking-of-brass-in-ammonia/>

corrosion products were recorded before the test samples were cleaned. The test samples were cleaned and rinsed in the pickling solution of 1M sulphuric acid solution in order to remove corrosion products formed on the surface of brass followed by rinsing with deionised water. Finally the samples were dried with tissues before being examined under an optical microscope for stress-corrosion cracking.

RESULT AND DISCUSSION:

Sample observation after exposure of 4 days to test solutions:

Test

Label

Test

Observation from visual examination and optical microscopy

Reason

1

Brass sample immersed in solution A

Solution remained pale blue. No cracks were seen. corrosion products found. Localized Corrosion damage at the stressed area observed back of the sample

Stress-corrosion cracking may occur with further exposure to the solution.

2

Brass sample immersed in solution B for 4 days

Solution was darker compared to the original solution. Brass sample in tarnish condition (dark brown colouration). Crack at the stressed end.

Stress-corrosion cracking of the sample.

3

Brass sample immersed in solution C

No significant change in solution colour. No cracks were seen. corrosion products found.

Sample shows low possibilities to SCC

4

Brass sample immersed in solution D

Dark brown corrosion products. Localized corrosion damage at the stressed end. No cracks seen.

Stress-corrosion cracking may occur with further exposure to the solution.

5

Brass sample immersed in solution E

Solution changed from colourless to light pale blue. Cracks seen.

Colour change is likely due to formation of cupric ion, Cu^{2+} . Stress-corrosion cracking at the stressed end.

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6

Brass sample suspended above solution E

Solution remained colourless. Tarnish film covering almost the entire surface.

Cracks seen at stressed region

Stress-corrosion cracking of the sample at the stressed end. Tarnish film likely to be cuprous oxide, Cu_2O .

Sample A:-

A-1 A-2

Fig 1: Sample ' A ' immersed for 4 days in solution Ammonium Sulphate with copper (II):

0. 5M $(\text{NH}_4)\text{SO}_4$ + 0. 05M CuSO_4

OBSERVATION: No stress corrosion cracking observed at the stressed end of the sample Fig A-1. some corrosion product was noticed on the back side of the sample Fig A-2.

Sample B:-

B-1 B-2

Fig 2: Sample ' B ' immersed for 4 days in solution Ammonia solution with copper (II):

2. 5M NH_4OH + 0. 05M CuSO_4

OBSERVATION: Stress corrosion cracking observed at the stress end and near the unstressed region just near to the stressed end Fig B-1. Dark corrosion product observed on the backside of the sample Fig B-2.

Nature of cracks: Intergranular

Sample C:-

C-1 C-2

Fig 3: Sample ' C ' immersed for 4 days in Mattson's solution at pH of 7. 2

OBSERVATION: No cracking or any other significant changes observed in this sample after even 4 days of exposure. Only dark corrosion products were observed on the sample.

Sample D:-

D-1

Fig 4: Sample ' D ' immersed for 4 days in Modified Mattson's solution containing 5% by

volume of 0. 1M NaCl

OBSERVATION: No cracking or any other significant changes observed in this sample after even 4 days of exposure. Only dark corrosion products were observed on the sample.

Sample E:-

Fig: E-1 Fig: E-2

Fig 5: Sample ' D ' immersed for 4 days in 1M ammonia solution.

OBSERVATION: Stress corrosion cracking observed at the stress end extending to the edges and Dark corrosion product observed on the backside of the sample Fig E-1 and E-2.

Nature of cracks: Intergranular

Sample F:-

Fig: F-1 Fig: F-2

Fig 5: Sample ' D' suspended above in 1M ammonia solution for 4 days.

OBSERVATION: Stress corrosion cracking observed at the stress end extending to the edges and Dark corrosion product observed on the backside of the sample Fig F-1 and F-2.

Nature of cracks: Intergranular.

From Optical microscopy analysis it is evident that sample B (Fig 2 - B1&B2) immersed in a test solution containing Ammonia solution with copper (II): 2.5M NH₄OH + 0.05M CuSO₄, Sample E (Fig5-E1&E2) suspended above the test solution of 1M Ammonia solution and Sample F (Fig6 - F1&F2) suspended above the test solution of 1M Ammonia solution had undergone stress corrosion cracking and shows that only in some particular environment SCC occurs. Apart from stress corrosion cracking dark tarnish corrosion product was observed which could possibly be oxide layer of copper.

Rest of the three samples - A (Fig1 - A1& A2) immersed in a test solution containing Ammonium Sulphate with copper (II): 0.5M (NH₄)SO₄ + 0.05M CuSO₄,

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C (Fig 3 - C1&C2) immersed in a test solution of Mattsson's solution at pH 7. 2 and D (Fig 4 - D) immersed in a test solution of Modified Mattson's solution containing 5% by

Volume of 0. 1M NaCl did not show any cracking but had tarnish corrosion product. These samples suffered localized corrosion at the stressed edges which can be seen in back side of the above 3 samples (Fig A2 &C2).

The electrochemical reactions of brass in ammonia environment are as follows:

Copper free aqueous ammonia is oxygen reduction and primary oxidation reaction is oxidation of copper to form cuprous complex ions.



The cuprous complex ions formed further reacts with oxygen forming cupric complex ions



Cuprous complex ion cupric complex ion

The formation of cupric complex ions leads to stress corrosion cracking of brass in ammonia solutions. The process does not proceed indefinitely since the attack of cupric complex ion (oxide layer) occurs at critical copper ion content which leads to decrease in corrosion rate but the cracking continues with the copper ion concentration.

It is also evident from the black dark coloured product formed (Tarnish colour) on the surface that the cracks are intergranular in nature. The pores on the surface of the corrosion product were the sites for localized attack, likely to survive at the grain boundaries. In general the stress corrosion cracking in $\hat{\pm}$ brass has considered being intergranular. On absence of the black coloured corrosion product it is believed that the cracks to be transgranular nature of crack.

CONCLUSION:

It is evident from the discussion carried out above that brass is susceptible to stress corrosion cracking in ammonia. Stress corrosion cracking was observed in the regions where residual stresses were generated leaving behind the rest of the areas which were not induced to stress. Formation of cupric complex ions leads to stress corrosion cracking of brass in ammonia solutions.

The cracks formed on the brass surface can be further studied under SEM to provide detailed information on the nature of the crack formed.

In order to overcome the above problem of stress corrosion cracking the following options can be opted

Eliminating any one of the primary factor (Environment, material and stress) will mitigate stress corrosion cracking.

Use of more cracking resistance alloys such as Cu-10Ni instead of Cu-Zn