Corrosion Effects on Secondary Processing of AISI 1018 Steel

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Abstract

This project details and evaluates the corrosion effects of a 5% salt fog on AISI 1018 steel samples of various secondary processes: machined, bead-blasted, coated, and coldworked over a period of 24 and 48 hours. Samples were weighed and measured before and after the salt-fog test to determine corrosion rates. Images were taken and used to document corrosion behaviors and comparisons between samples were made. The observed corrosion effects were as expected for all samples. The corrosion rate calculations were unreliable due to illegitimate and random errors made during the experiment.

Introduction

To find the effects of corrosion on various secondary material processes, a test must be performed in a corrosive environment. The test that was performed was intended to adhere to the ASTM standard B117. ASTM B117 is the global benchmark for salt spray corrosion testing, providing a controlled environment to compare how well materials resist corrosion. The standard requires that the testing setup use a salt spray chamber with a 5% sodium chloride (saline) solution maintained at 95°F to create a salty fog. This test can run for various periods of time. This test used two samples of steel for each type of secondary possess. One of each sample was removed from testing at hour 24 and hour 48.

All specimens were coldworked. Coldworking plasticly deforms the surface of a metal and can increase dislocation density as well as tensile and compressive residual stresses. Two of the specimens did not have additional processing,. The remaining samples had a secondary process applied such as bead-blasting, powder-coating and machining. Bead-blasting is an abrasive cleaning method that roughens the surface, potentially introducing compressive residual stresses. Coating, provides a physical barrier between the metal and the corrosive environment and should lead to very little instances of corrosion. Machining alters the surface finish and leaves cutter tool grooves which may trap corrosion, tensile and compressive residual stresses will also be introduced. Coldworking, bead-blasting and machining will all likely create residual stresses. Residual stresses may accelerate or slow cracking depending if they are tensile or compressive. The tensile residual stresses "pull" the material apart at the microscopic level and aids corrosion in opening localized areas for corrosion pitting to occur. This drives crack growth making corrosion appear sooner. Compressive residual stresses on the other hand can offset this phenomena.

Methods

- Images were taken to visually document corrosion effects.
- Corrosion Rate was calculated using the formula from the 2015 T&R Bulletin with variables and constants clarified by NACE.

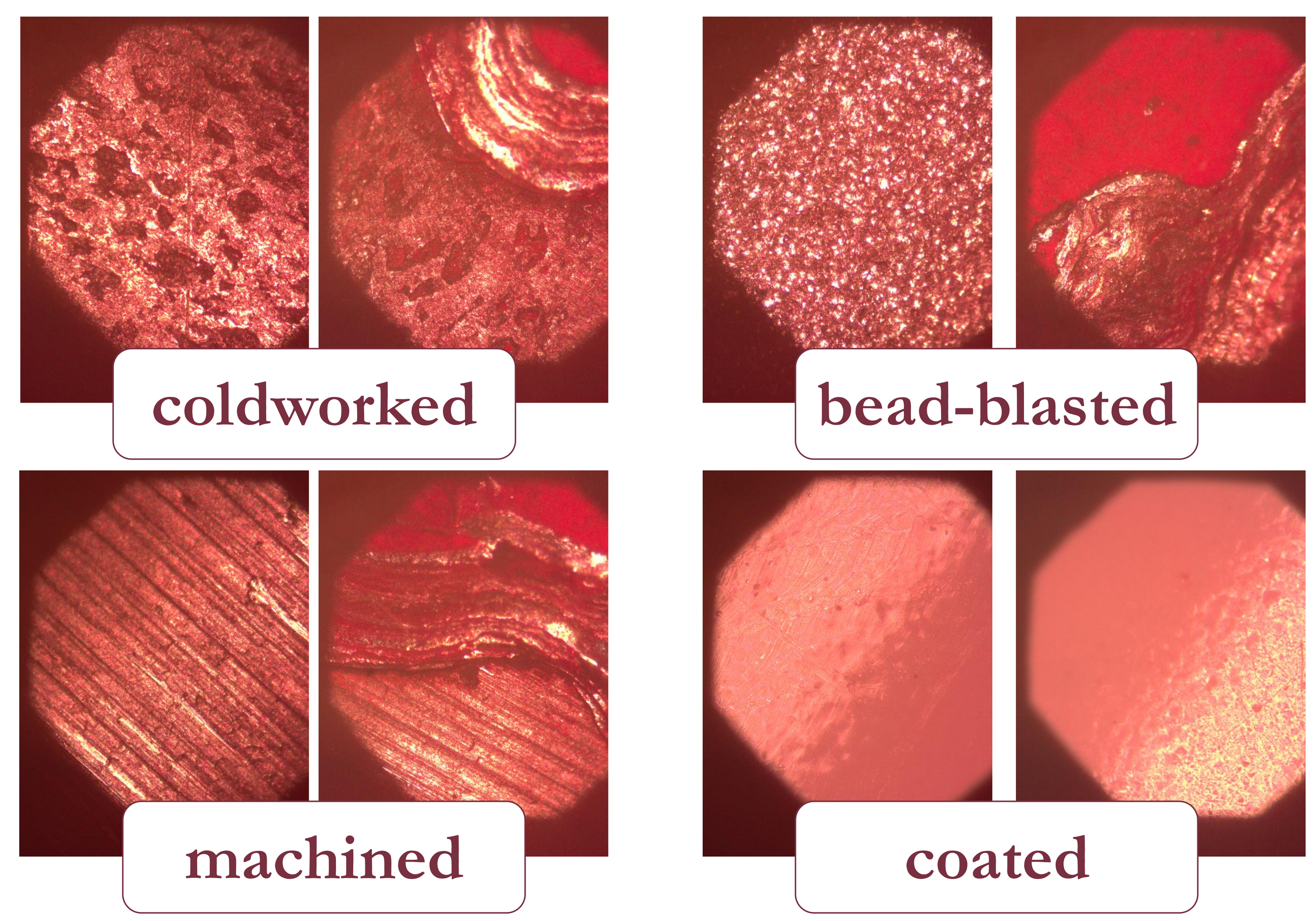
[2] $CR = \frac{K*W}{A_{surf}*t*\rho}$ Equation (1.4.25)

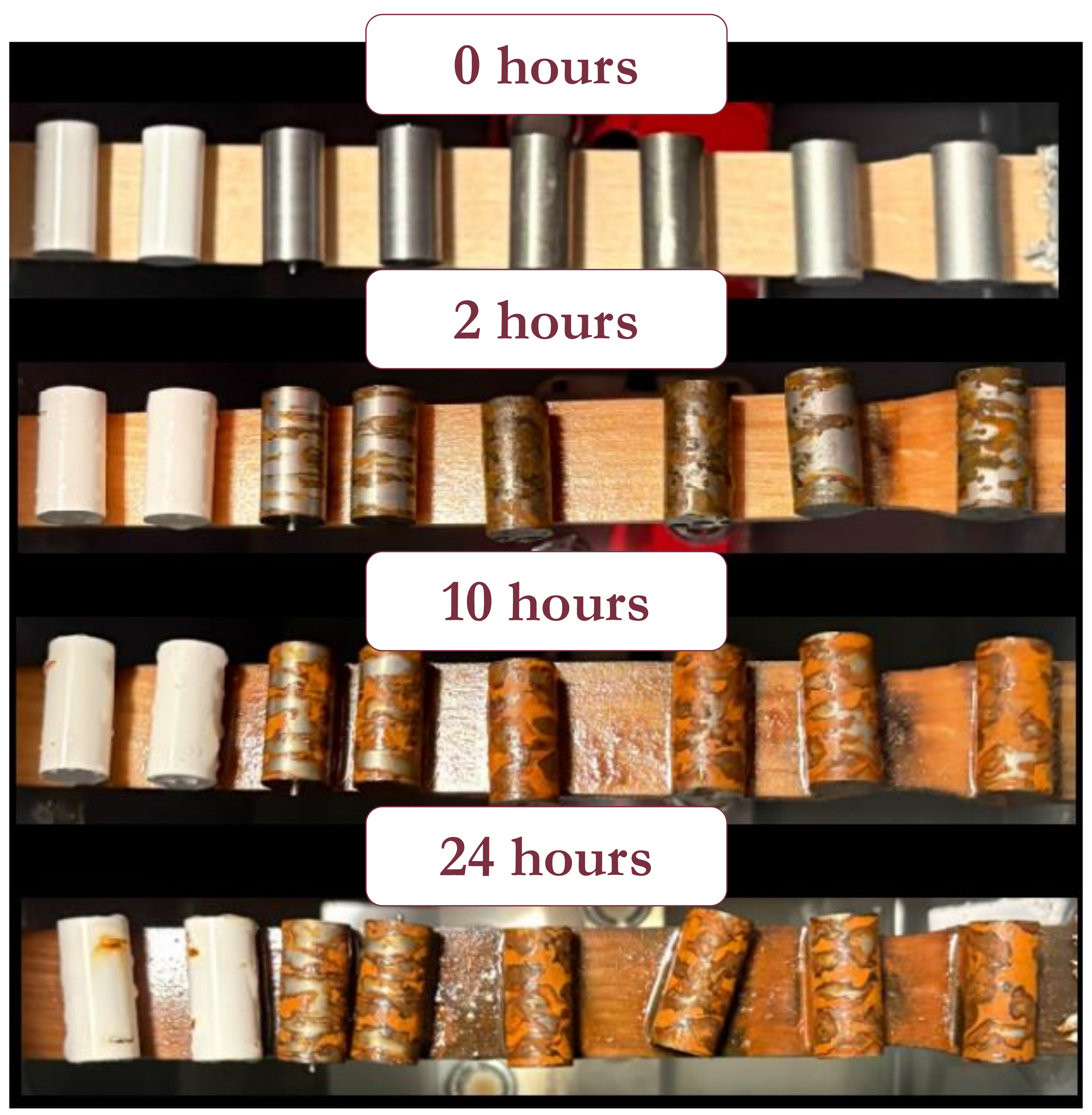
[3]

CR = corrosion rate (mm/year)
W = mass (mg)
A = exposed area (cm^2)
t = time of exposure (hours)
ρ = density (7.87 g/cm^3) [4]
K = material constant (8.76×10^4 mm/year) [3]

Note: The exposed surface area, "A" will be simplified to diameter * PI * length.

Results





$CR_{STOCK,24}$ = 2613 mm/yr

$CR_{STOCK,48}$ = - 1304 mm/yr

$CR_{BLASTED,24}$ = 0 mm/yr

$CR_{BLASTED,48}$ = 0 mm/yr

$CR_{COATED,24}$ = - 2580 mm/yr

$CR_{COATED,48}$ = - 1289 mm/yr

$CR_{MACHINED,24}$ = 2582 mm/yr

$CR_{MACHINED,48}$ = 0 mm/yr

Discussion

After examining the pictures taken of the specimens before, during and after testing, the corrosion behaviors of all the specimens acted as predicted. The bead-blasted specimen resisted corrosion pitting within the first two hours in comparison to the plain cold-worked specimen likely due to the added compressive residual stresses. The machined specimen initially corroded in the tool grooves and then spread outward as opposed to the blotchy corrosion pattern of the other two uncoated samples. The coated specimen resisted all corrosion other than at the points in which it was mounted, which were uncoated. A transition area was also observed between the corroded and non-corroded portions of the materials, which represents the active front of the corrosion and appeared to have a wave-like shape. Due to errors including a variable testing temperature and an exposure time that was not long enough to see significant wastage, the calculations of corrosion rate for all specimens are not reliable.

Conclusions

1. Compared to the corrosion in the coldworked samples:
   - Bead-blasted samples resisted some corrosion most likely due to added compressive residual stresses.
   - Machined samples experienced concentrated corrosion due cervices created by a cutting tool.
   - Coated samples experienced little to no corrosion.
2. Calculations of Corrosion rate are unreliable due to random and illegitimate errors.

References

1. ASTM International. *ASTM B117-19: Standard Practice for Operating Salt Spray (Fog) Apparatus*. ASTM International, 2019.
2. Transportation Research Board. *Guide to Materials*. T&R Bulletin, 2015.
3. NACE International. *The Math Behind Corrosion Rates: NACE SP0775*. NACE International, 2015.
4. MW Components. *Carbon Steel Grade 1018 Data Sheet*. Elgin Material Sheets, 2015, www.mwcomponents.com/uploads/Resource-Center/Elgin-Material-Sheets/Carbon-Steel-Grade-1018-Data-Sheet_Elgin.pdf..