Stress Corrosion Cracking of Duplex Stainless Steels in Caustic Solutions

- DSS is characterized by:
  - Dual microstructure (roughly equal volume fraction of ferrite and austenite by volume)
  - Balanced microstructure and high Cr and Ni content provides superior mechanical and corrosion properties

- Current operating environments in Pulp and Paper industries cause SCC in DSS
- High temperature
- Increased concentration of chemicals
- Different equipment fabrication processes
- SC cracks observed in Pulp and Paper mills
- Pressure vessels
- High stress components
- Change in microstructure and environmental conditions causing SCC of DSS in caustic solutions not known

Motivation

- Slow strain rate tests of tensile specimens of 2205, 2101 and 2003 DSS
- Caustic solution
- High pressure autoclave
- Temperature (120°C-200°C)
- Initial strain rate of 2x10^-1 s^-1
- Open circuit potential
- SSRT in inert environment for comparison

Experimental Approach

SCC Susceptibility

Characterization and analysis of the effects of Cellulosic Ethanol on Corrosion and Stress Corrosion Cracking of Pipeline Steel

- Pipeline is an efficient and clean mode of transport for fuel
- Very little research has been done on corrosion of pipeline steel due to ethanol and other renewable fuels

Experimental Methods

- Continuous Extension at Initial Strain Rate of ~ 2 x 10^4 s^-1
- SCC of 2205 DSS sand separator
- SCC in 2205 DSS white liquor accumulator

Corrosion Fatigue of Duplex Stainless Steels

- What is CF?
- Damage and failure of a material under the combined action of cyclic stresses and corrosive environments
- Motivations?
  - Many structures are actually undergoing very low cycle fatigue in various corrosive environments
  - Very little work has been done about CF of DSS, either in low pH or high pH environment

TO AVOID HAZARDS AND EXPENSES DUE TO CORROSION, MUCH RESEARCH MUST BE DONE BEFORE ETHANOL CAN BE TRANSPORTED VIA PIPELINE

Identify Challenges Facing Pipeline Transport of Ethanol

Cellulosic ethanol contains a spectrum of contaminants

- We want to know what they are and how they affect the corrosion performance of pipeline steels
- Analyze contaminant content in various cellulosic ethanol
- Characterize corrosion behavior of pipeline steel in ethanol
- Propose mechanism of stress corrosion cracking (SCC) in the steel

Experimental Methods

- Chemical analysis of cellulosic ethanol by gas chromatography, mass spectrometry and in-situ Raman spectroscopy
- Electrochemical Material Characterization via Potentiostatic polarization and impedance spectroscopy
- Weight loss tests to determine corrosion rate
- Slow strain rate (SSR) tests in ethanol-containing load cells

"Mechanisms of Stress Corrosion Cracking in Duplex Stainless Steels used in Caustic Solutions"

The objective of this research will be to develop a fundamental understanding of the mechanisms that give rise to stress corrosion cracking (SCC) in duplex stainless steels (DSS) used in the sulfide-containing, caustic environments of the pulp and paper industry. This research effort will implement in situ techniques to monitor the electrochemical parameters on the surface that lead to destruction of the passive film and subsequent crack propagation into the bulk material. These results will hopefully ensure reliable material performance by facilitating proper material selection under particular environmental considerations.