Program and Abstracts

INTERNATIONAL CONFERENCE ON

HYDROGEN EFFECTS ON MATERIAL BEHAVIOR
and
CORROSION DEFORMATION INTERACTIONS

H-CDI

Jackson Lake Lodge, Moran, WY
September 22-26, 2002

International Conference On

HYDROGEN EFFECTS ON MATERIAL BEHAVIOR
and
CORROSION DEFORMATION INTERACTIONS

Jackson Lake Lodge
Moran, Wyoming USA
September 22-26, 2002

Sponsored by

Joint TMS/ASM Environmental Effects Committee, Structural Materials Division, TMS
Environment Sensitive Fracture Working Group, European Federation of Corrosion
National Institute of Standards and Technology
Sandia National Laboratories

Endorsed by

Materials Research Society

Program Committee

Russell Jones, Pacific Northwest National Laboratory
Neville Moody, Sandia National Laboratories
Anthony Thompson, Lawrence Berkeley Laboratory
Thierry Magnin, Ecole des Mines de St. Etienne
Richard Ricker, National Institute of Standards and Technology
Gary Was, University of Michigan

Support Provided by

National Institute of Standards and Technology
Sandia National Laboratories
Structural Materials Division, TMS

Conference Chairs

Neville Moody
Sandia National Laboratories
Livermore, CA 94551-0969
nrmoody@sandia.gov

Anthony Thompson
University of California
Berkeley, CA 94720
awthompson@lbl.gov

Richard Ricker
NIST
Gaithersburg, MD 20899
richard.ricker@nist.gov

Gary Was
University of Michigan
Ann Arbor, MI 48109
gsw@umich.edu

Thierry Magnin
Ecole des Mines de St. Etienne
42023 Saint Etienne France
magnin@emse.fr

difficult. Vacancies generated by corrosion are consumed by dislocation climb which enhances creep, but later agglomeration of vacancies under applied stress results in cleavage-like stress corrosion cracking or intergranular stress corrosion cracking depending on the loading conditions.

Surface Work Hardening and Stress Corrosion Cracking of an Austenitic Stainless Steel.
C. Braham, A. Bouzina, J. Lédion, CNRS ESA, Paris, France

The influence of material work hardening on stress corrosion cracking still remains a controversial subject. The aim of the present study is to quantify the effect of work hardening on the stress corrosion cracking behaviour of an austenitic stainless steel type AISI 316L. Classical tests under applied loading were conducted in a boiling (117°C) 30% magnesium chloride aqueous solution. Particular attention was given to the preparation of the surfaces. The referential specimen was obtained through a mill annealed treatment and the surface was prepared by electrochemical polishing in order to obtain a material without work hardening and residual stresses. Three surface states were studied: machined (turned), polished using abrasive paper and shot peened. Residual stress corrosion cracking tests were carried out in a 44% magnesium chloride solution at boiling temperature (154°C). X ray diffraction provided the thickness of the work hardening layer and the stress distribution in depth for each specimen. Using the same technique, the stress distribution during the tensile loading was determined. A variation of residual stress distribution is observed even for a weak loading. On the shot peened surface the compressive stress was modified. This was confirmed by corrosion tests which led some cracks in the material: the most hardened specimen (shot peened) cracked first.

The assumption given by the authors is that, in work hardenable materials like the AISI 316L SS, the plastic deformation of the surface changes the material behaviour. A numerical simulation, with a finite element method showed how to take into account surface work hardening of material. The tensile specimen could be considered as a material consisting of thin layers with a high elastic yield and a bulk region with large deformation. This explains why the high compressed surface by shot peening can easily be changed into tension under a weak loading and makes stress corrosion cracking possible.

Effect of Nitrogen on the SCC of 316LN Weld Metal. S.N. Soman, M.S. University, Vadodara, India, V.J. Gadgil, University of Twente, Enschede, The Netherlands, S.N. Malhotra, M.S. University, Vadodara, India, R. Raman, V.S. Raja, S.D. Kulkarni, Indian Institute of Technology Bombay, Mumbai, India

Austenitic stainless steels containing nitrogen find extensive application in the industry because of improved corrosion resistance and higher mechanical strength. Nitrogen has beneficial effect on localised corrosion like pitting, crevice and intergranular corrosion. It is also reported that nitrogen reduces resistance to stress corrosion cracking (SCC). During fusion welding of the nitrogen bearing stainless steels, nitrogen has to be introduced in the weld metal to maintain similar levels of nitrogen in the base metal and the weld metal. This can be achieved by using nitrogen containing filler metal. A second possibility is to introduce nitrides or other sources of nitrogen to the flux. A third method is to add nitrogen to the shielding gas in gas tungsten arc welding (GTAW) or gas metal arc welding (GMAW). During welding nitrogen in the shielding gas is taken up by the molten weld pool. This is dependent on the thermodynamic equilibrium conditions in the arc plasma and molten weld pool. It is well known that small variations in nitrogen content can influence the corrosion behavior of the weld. In this investigation the effect of nitrogen content in the weld metal on the SCC behavior of GTAW welds of 316LN stainless steel was investigated. Filler metal used for the welds was 316L. The nitrogen content of the shielding gas argon was changed using a gas mixer. After welding, the nitrogen content of the weld metal was analyzed using melting and vacuum extraction method in a Leybold Heraeus NOA 2003 instrument. The susceptibility to SCC was evaluated using slow strain rate tests (SSRT) in 1 N HCl. Tests were carried out at a strain rate of 5×10^{-6}. Time-to-failure was considered as the indication of susceptibility to SCC. Results of SSRT tests are presented. Results of SSRT tests in air are used for comparison as nitrogen also influences mechanical strength. The fractures were investigated using a Hitachi S-800 scanning electron microscope. The fractographic features are discussed with respect to the mechanism of SCC failure. Influence of nitrogen on the SCC susceptibility of GTAW welds is discussed.

Effects of Thermohydrogen Processing on Microstructure and Properties of Uranium Alloys. M.B. Shuai, Y.J. Su, D.M. Lang, Z.H. Wang, P.J. Zhao, S. Wu, China Academy of Engineering Physics, Mianyang, China

The application of thermohydrogen processing (THP), that consists of using hydrogen as a temporary alloying element to modify the microstructures and improve final mechanical and corrosion properties of several uranium alloys, was presented. It was found that after thermohydrogen processing, a refinement in the microstructure with less nonmetallic element impurities, more pure phase constituent and more fine grain was achieved. The microstructural refinement led to an improved ductility, without large loss of strength, and significantly improved corrosion property. Some possible mechanisms of the effects of THP on the microstructures and mechanical/corrosion properties of uranium alloys were proposed.

Phase Transformations in Ti-6Al-4V-xH Alloys. J.I. Qazi, J. Rahim, O.N. Senkov, S.N. Patankar, F.H. Froes, University of Idaho, Moscow, ID, USA

Ti-6Al-4V alloy specimens containing 0, 10, 20 and 30 at.% hydrogen were prepared. Microstructures, phases and phase transformations were then determined in the temperature range of 20 to 1000°C using optical microscopy, transmission electron microscopy, X-ray diffraction and microhardness measurements. Alloying with hydrogen was achieved by exposure of specimens to different hydrogen partial pressures at 780°C. Increasing the hydrogen content from 0 to 30 at.% lowered the beta transus temperature of the alloy from 1005°C to 815°C, significantly slowed down the kinetics of beta-to-alpha transformation and led to formation of orthorhombic martensite instead of hexagonal martensite in quenched specimens. A hydride phase was also detected in the specimens containing 20 to 30 at.% hydrogen. The martensite decomposition behavior and beta phase time-temperature-transformation (TTT) diagrams were determined for different hydrogen concentrations.

Influence of Hydrogen on the β-phase Stability in Ti-Nb Alloys. D. Zander, B. Kofmann, D. Eliezer, Ben Gurion University of the Negev, Beer-Sheva, Israel, E.Y. Gutmanas, Technion, Haifa, Israel, D. Olson, Colorado School of Mines, Golden, CO, USA

The use of hydrogen as a temporary alloying element can strongly enhance fabrication of Ti-based alloys for example due to lower stresses and/or lower temperatures. In addition in refractory metals or alloys hydrogen has a large potential to promote superplasticity. It is known that in bcc metals, e.g. in iron, hydrogen enhances plasticity, since segregation of hydrogen at dislocations lowers their stress field. Furthermore hydrogen-assisted processing can lead to refined microstructures with improved mechanical properties. Until now some work has been conducted on processing and mechanical behavior of Ti-Nb alloys, but very little is known on the microstructural changes associated with hydrogen-assisted metal forming and transformation