PRELIMINARY PROGRAM

---Monday, October 4, 2010---

08:30
Room: Oxford (Conv-3rd Flr)
Stream: FRACTURE CONTROL IN ENGINEERING
Session: Pipeline Cracking & Fatigue (MONAM1)

Paper Start Time: 08:30
Paper No.: 5162
Paper Title: **Evaluation of Crack and Corrosion Defects in an API X-60 Gas Pipeline Steel**
A. Hosseini, University of Waterloo; D. Cronin, University of Waterloo; A. Plumtree, University of Waterloo;
Full-scale rupture tests were conducted on 508 mm (20 in) diameter API X-60 5.7 mm wall thickness pipes containing either axial semi-elliptical cracks or simulated corrosion defects with equivalent depths ranging from 20 to 60 percent thickness. In the case of the cracks, the failure pressures were predicted with reasonable accuracy when considering a level 3 failure assessment diagram (FAD) procedure based on API 579, as compared to level 2 FAD, since the mechanical properties were known. In both cases, the accuracy improved for shallower cracks. Considering simulated corrosion defects, the RSTRENG approach provided more reliable results on predicting the collapse pressure. For a similar depth and profile, the cracked pipes failed at a lower pressure than those containing simulated corrosion defects of equivalent depth.

Paper Start Time: 08:55
Paper No.: 5358
Paper Title: **Assessment Methodologies for Girth Weld Defects in Pipelines**
William Tyson; MTL/CANMET; Su Xu, MTL/CANMET; Da-Ming Duan, TransCanadaPipeLines Ltd.;
Imperfections such as lack-of-fusion and undercut are inevitable in field welding of pipelines. Above a certain size, such defects must be removed or repaired. In the present state of the art, determination of allowable defect size is done by Engineering Critical Assessment (ECA). This requires measurement of toughness, and comparison of toughness with crack driving force. ECA methods used in current international pipeline standards will be reviewed and compared.

Paper Start Time: 09:20
Paper No.: 5151
Paper Title: **Local Additional Potential Model for the Effect of Strain Rate on SCC of Pipeline Steel**
Frank Cheng; University of Calgary; Zhiyong Liu, University of Calgary; Xiaogang Li, Univeristy of Sci. and Techno. Beijing; Cuiwei Du, University of Sci. and Techno. Beijing;
Stress corrosion cracking (SCC) behavior of X70 pipeline steel in an acidic soil solution was investigated by slow strain rate test, surface characterization, potentiodynamic polarization measurement and electrochemical hydrogen permeation technique. A local additional potential model (LAPM) was developed to illustrate the critical role of strain rate in SCC of the steel. According to LAPM, both density and mobility of local active spots on the steel surface, i.e., dislocation emergence point, increase linearly with strain rate. Generation of such active spots introduces an additional negative potential locally, affecting the electrochemical reaction and, consequently, the susceptibility of the steel to SCC. When strain rate is sufficiently high, the mobility of the dislocation emergence points is so fast that the reactive species in solution cannot combine with them for cathodic reaction, resulting in a decrease of the SCC susceptibility. Diffusion of hydrogen atoms in a strained steel is through both body diffusion and dislocation diffusion, with the latter enhanced by an increasing strain rate. When strain rate is so high that the dislocation mobility is sufficiently fast, hydrogen atoms become incapable of catching up with the dislocations. As a result, the hydrogen diffusion is dominated by the body diffusion mode.

Paper Start Time: 09:45
Paper No.: 5161
Paper Title: **High Cycle Fatigue Behaviour of Forged Shot-peened Crackable Air Cooled Steel**
Alan Plumtree; Mechanical and Mechatronics Eng, University of Waterloo;
Air cooled crackable and conventional forged steel specimens were tested under reversed push-pull conditions to examine the effect of shot-peening on their high cycle fatigue behaviour. The steels were tested in the normalized as well as shot peened conditions. The results showed that shot peening smooth specimens had little effect on the fatigue limit of the air cooled forged steels, and the detrimental effect of the rougher peened surface was not apparent. Since shot peening produced a gradient of residual compressive stresses that was greater than that of the loading stresses, the anticipated beneficial effect on fatigue life was suppressed, and crack initiation was more likely to occur below the surface. It is suggested that work hardening caused by shot peening was more beneficial in improving the fatigue strength than the accompanying induced residual compressive stresses.

10:30
Room: Oxford (Conv-3rd Flr)
Stream: FRACTURE CONTROL IN ENGINEERING
Session: Pipeline Cracking & Fatigue (MONAM2)

Paper Start Time: 10:30
Paper No.: 5128
Paper Title: **Low Cycle Fatigue Testing of Weld Built-up Panels**
Shona R. McLaughlin; DRDC Atlantic; Eric Clark, University of Victoria; Christopher J. Bayley, DRDC Atlantic;
The deposition of weld metal to reclaim lost thickness due to corrosion damage is a widespread industrial practice. However, the distortion and residual stresses due to the welding develop complex stress-states, even in relatively simple geometries. The current research focuses on the effects of residual stresses due to weld repair on the low cycle fatigue life. The through thickness residual stresses were characterized in two HY-80 steel panels with different sized welded patches. These panels were then subjected to biaxial fatigue tests with a peak load of 75% of yield. Results and the impact of patch size will be discussed.

Paper Start Time: 10:55
Paper No.: 5092
Paper Title: **Analysis of LEFM Parameters and Fatigue Propagation of SENT Cracked AM60B Magnesium Specimens**
Md. Nur Hossain; Dalhousie University; Farid Taheri, Dalhousie University;
Analysis of Linear Elastic Fracture Mechanics (LEFM) parameters via the Virtual Crack Closure Technique (VCCT) has been obtained for SENT specimens of AM60B magnesium alloy. It is found that the ratio of initial crack length to initial monotonic plastic zone size is one of the critical factors in establishing the limit of using LEFM concepts. If this ratio is below a certain limit (i.e. when crack lengths are small in comparison to the plastic zone size), loss of similitude stress intensity factor range would occur. This ratio, therefore describes the limit below which the use of LEFM would no longer be admissible. In this study, the above limit was established for AM60B magnesium alloy. In addition, fatigue crack propagation tests were conducted to ascertain the fatigue response of the alloy and determination of the coefficients of Paris model.

Paper Start Time: 11:20
Paper No.: 5264
Paper Title: **Enhancement and Analysis of Cracking Resistance in Thermal Barrier Coating for Gas Turbine Applications**
Amar Kumar; Tecsis Corporation ; Venkatraman Narasimhan, University of Ottawa; Amiya Nayak, University of Ottawa; Alka Srivastava, Tecsis Corporation; Nita Goel, Tecsis Corporation;
Thermal barrier coating (TBC) systems provide thermal insulation to high temperature for aero-propulsion. Performance reliability with long durability and structural integrity are the two most demanding criteria for TBCs. Integration of physics of damaging events and mechanics of TBC instability is the ultimate solution to mitigate the challenge. Objective of the work is to address the fracture mechanistic analysis with multilayer TBC to model the mechanics of failure and enhance the cracking resistance. Experimental work with plasma sprayed TBC under thermal cycling has been conducted to model the physics of failure process. Two physical damaging events, namely thermally grown oxide layer and microcracking are observed and quantitatively characterized. Stress intensity factor is estimated at the interface between the layers. In order to reduce the stress intensity level and enhance cracking resistance, a number of layers are considered for analysis. Various parameters like number, composition and thickness of layers are considered in the study to optimize the improvements and the cost involved in multilayered TBC coating design.

Paper Start Time: 11:45
Paper No.: 5149
Paper Title: **Microstructure of X100 Pipeline Steel and the Implication on its Susceptibility to Hydrogen-induced Cracking**
Frank Cheng; University of Calgary; Taiyan Jin, University of Calgary; Zhiyong Liu, University of Calgary;
In this work, the microstructure of X100 pipeline steel was characterized by scanning electron microscopy and energy-dispersive x-ray analysis, and the hydrogen-induced cracking (HIC) susceptibility of the steel was studied by the cathodic charginbg method. The relationship between the microstructure and the HIC behavior was established. It was found that four types of inclusions exist in X100 steel, with the compositions containing primarily Al, Si, Ca, Mn and S. The majority of inclusions are spherical in shape, enriching in Al. Furthermore, cathodic charging could result in HIC of the steel. The crack occurrence is always associated with the Al-enriched inclusions. The susceptibility of the steel to HIC increases with the charging current density. A critical hydrogen amount to cause cracking was determined.

14:00
Room: Oxford (Conv-3rd Flr)
Stream: FRACTURE CONTROL IN ENGINEERING
Session: Modeling & Characterization (MONPM1)

Paper Start Time: 14:00
Paper No.: 5485
Paper Title: **Modeling of Time-dependent Damage Evolution in Multidirectional Polymer Composite Laminates**
Amir Asadi; University of Manitoba; Raghavan Jayaraman, University of Manitoba;
Time-dependent evolution of various damage modes such as transverse cracking, vertical cracking, delamination, and fiber fracture as well as the interaction among them influence the time-dependent degradation in modulus (creep) and strength (creep rupture) of polymer composite laminates. This study is focused on modeling of time-dependent evolution of transverse cracking in various plies of a multidirectional polymer composite laminate. A model based on critical stored elastic energy criterion has been developed to predict time-dependent evolution of damage during creep. This model is based on two-dimensional variational analysis to determine the stress state and the elastic stored energy in the entire laminate, which is subsequently compared with a critical value required to form a new crack in order to determine the crack evolution.

Paper Start Time: 14:25
Paper No.: 5336
Paper Title: **A Dual Bound Approach to Damage-based Finite-element Modeling of Tube Hydroforming**
Zengtao/ZT Chen; University of New Brunswick; Cliff James Butcher, University of New Brunswick; Alex Bardelcik, University of Waterloo; Michael James Worswick, University of Waterloo;
Numerical simulations of straight tube hydroforming of a dual phase steel were performed using both upper and lower bound constitutive models for porous ductile materials. The widely used Gurson (1977) model is based upon an upper bound approximation to the material behavior and thus overestimates formability. Conversely, a little known lower bound solution to Gurson's unit cell geometry was developed by Sun and Wang (1989) to provide a conservative estimate of formability. The Gurson and Sun and Wang models are applied to a tube hydroforming operation to generate a formability band and capture the actual material behaviour. The effect of a compressive axial load (end-feed) on damage development and tube formability is investigated for end-feed loads of zero and 133 kN. A parametric study was conducted to calibrate the void nucleation model and the resulting formability band compared with experiment. The resulting upper and lower bound models successfully captured the experimentally determined burst pressure, formability and failure location for each end-feed case.

Paper Start Time: 14:50
Paper No.: 5188
Paper Title: **Advanced Testing and Modelling of Hydrogen Embrittlement**
Wolfgang Dietzel; GKSS-Forschungszentrum Geesthacht GmbH;
Fracture mechanics based techniques are suited to gain insight into the phenomenon of stress corrosion cracking (SCC) and to develop guidance for avoiding or controlling SCC. From constant extension rate experiments under rising load or rising displacement conditions the susceptibility of high strength steels, aluminium, magnesium and titanium alloys to SCC and hydrogen embrittlement (HE) can be characterised. Such tests on pre-cracked specimens have proven to be also well suited for studying the underlying SCC mechanisms by applying appropriate models of the degradation of metallic materials caused by the uptake of atomic hydrogen from the corrosive environment. Measurements of the crack tip opening angle, CTOA and the relationship between the crack growth velocity and the applied deformation rate can be linked with model calculations that simulate the mechanism leading to HE. In this work, the results of constant extension rate SCC experiments on specimens made from a high strength steel and from magnesium alloys will be presented and will be discussed in comparison with data obtained from model calculations simulating the same combination of mechanical stresses and corrosive environments leading to hydrogen embrittlement.

15:35
Room: Oxford (Conv-3rd Flr)
Stream: FRACTURE CONTROL IN ENGINEERING
Session: Modeling & Characterization (MONPM2)

Paper Start Time: 15:35
Paper No.: 5135
Paper Title: **The Influence of Plastic Anisotropy and Damage on the Crack Propagation Behaviour of Zr-2.5Nb Pressure Tube Material**
Bruce W. Williams; AECL; Sterling St Lawrence, AECL; Brian Leitch, AECL;
The crack propagation behaviour of Zr-2.5Nb pressure tube material was studied through comparison of the measured behaviour with the predicted response from finite element analysis. Three-dimensional finite element simulations of compact tension specimens were performed using the crack tip opening angle as a fracture criterion to allow for crack propagation. To obtain reasonable agreement with the measured behaviour, it was important to capture both the anisotropic plastic deformation behaviour of the Zr-2.5Nb material through use of the Hill-48 yield criterion and damage due to void nucleation and growth through use of a Gurson-based constitutive model in the

simulations.

Paper Start Time: 16:00
Paper No.: 5419
Paper Title: **Fracture Characterization of a Representative Welded Ship Panel**
Christopher J. Bayley; Defence Research Development Canada; Michael Verteeg, University of Victoria;
HSLA-65 (ASTM A945-05) is a relatively new micro-alloyed steel suitable for naval construction with good base metal fracture and strength properties. However, of equal importance to these base metal properties are those of a weld's heat affected zone. The objective in this project is to determine the fracture behaviour of large scale single edge notched tension specimens which include characteristic weld geometries found in naval construction. These samples are representative of a flawed ship structural panel which is dynamically loaded at the minimum design temperature. These samples are initially notched and fatigue pre-cracked in the microstructural region associated with either the coarse grained heat affected zone or the weld metal. Companion numerical studies of similar panels reveal that the location of the crack in either the heat affected zone or weld alters the distribution of plastic strain. In particular the inhomogeneity of the weld creates an asymmetric strain field around the crack tip and, in these simulations, a crack located along the heat affected zone experiences the greatest crack driving force. Fracture toughness studies using similar welding procedures, consumables and base metal as the large scale specimens reveals that not only does a crack located along the heat affected zone have the greatest driving force, but it is also located in the least tough microstructural region. These conclusions on the fracture toughness were obtained from deeply notched single edge bend specimens which are known to provide conservative estimates due to their highly constrained crack front. Therefore, the objective of the present test is to examine whether brittle crack initiation is expected to occur in a structurally representative test piece which has significantly less crack tip constraints, and hence would be expected to have better toughness than expected from the fracture data.

Paper Start Time: 16:25
Paper No.: 5551
Paper Title: **Preparation and Characteration of Some New Polyesters**
A.H. Channar; University of Sindh; K.P. Mahar, Shah Abdul Latif University; M.Y. Khuhawar, University of Sindh;
The Schiff bases formed by the reaction of salicylaldehyde with ethylenediamine, propylenediamine, mesostilbendiamine and hydrazine were polymerized by the reaction with terephthaloy chloride. The polymers formed were characterized by IR, UV, elemental analysis, DTA/TGA and Viscosities measurements. The polymers indicated Interensic viscocities. In the range 0.573.

Paper Start Time: 16:50
Paper No.: 5510
Paper Title: **Relative Priority of the Application of Biomedical Alloys Employed in Bones Using Multi-attribute Decision Making TOPSIS**
Mohsen Siadat Cheraghi; University of Tehran; Naser Towhidi, University of Tehran; Saeed Reza Allah Karam, University of Tehran; Ruhollah Ghasemi, University of Tehran;
In selecting an appropriate biomedical alloy, several factors such as biocompatibility, corrosion and mechanical properties and also economic factors are effective. By using the experts' comments, pair-wise comparison tables were prepared by the principal criteria and the GAHP method. Weights of the subcriteria were obtained by way of the Entropy method. Vector of the final weight was acquired by combining the weight derived from the GAHP and the one from the Entropy method and using the modified Entropy method. Finally, by means of the TOPSIS, Ti6Al4V and G-Co29Cr5Mo alloys were chosen as the best and the worst alloys, receptively.