

WEDNESDAY, AUGUST 25, 2004, A.M.

SESSION 41B: SECOND INTERNATIONAL SYMPOSIUM ON AEROSPACE MATERIALS AND MANUFACTURING: DEVELOPMENT TESTING AND LIFE CYCLE ISSUES - HONORING WILLIAM WALLACE

Sponsor: Materials Performance and Integrity Section, The Metallurgical Society of CIM

Room: ALBION B

Chairmen: P.C. PATNAIK, M. JAHAZI, National Research Council – Institute for Aerospace Research, Ottawa, Ontario, Canada,

M. ELBOUJDAÏNI, CANMET, Ottawa, Ontario, Canada, and

J. LUO, University of Alberta, Edmonton, Alberta, Canada

PAPER 41B.1 — 8:30

MICROSTRUCTURAL CONTROL FOR CREEP RESISTANCE OF TITANIUM ALUMINIDE INTERMETALLICS

J. BEDDOES, Mechanical and Aerospace Engineering, Carleton University, Ottawa, Ontario, Canada

The various microstructural factors that influence the creep resistance of γ -titanium aluminides are presented and discussed. Titanium aluminides have potential for a variety of intermediate temperature applications in both gas turbine and reciprocating engines. While it is well established that the ‘fully lamellar’ titanium aluminide microstructure offers superior creep properties, the particular influence of lamellar morphology, third phase precipitation, and grain boundary structure in controlling both the primary and tertiary creep behaviour is presented. In addition the role of elastic lattice strain during creep deformation is explored through *in-situ* neutron diffraction experiments. The results are primarily based on tensile creep experiments undertaken using several titanium aluminide intermetallic compositions processed via powder metallurgical techniques, investment casting and Bridgman directional solidification. The results indicate that lamellar structure and precipitate formation have a major impact on primary creep, while microstructural degradation through both lamellar and precipitate coarsening influence on the onset of tertiary creep leading to fracture. Surprisingly, it is evident that elastic lattice strain can increase during creep deformation. The results are used to design a creep resistant microstructure produced by directional solidification and the effectiveness of this designed microstructure is demonstrated through 10,000 hour creep tests.

PAPER 41B.2 — 8:55

ADVANCED TECHNOLOGIES FOR REPAIR OF SINGLE CRYSTAL TURBINE BLADES

P.C. PATNAIK, A. MERATI, NRC-Institute for Aerospace Research, Structure, Materials and Propulsion Laboratory, Ottawa, Ontario, Canada

X. HUANG and J-F. THIBAUT, Department of Mechanical and Aerospace Engineering Carleton University, Ottawa, Ontario, Canada

Single-crystal nickel based superalloys are the current state-of-the-art technology for the manufacture of turbine blades. This technological improvement of the turbine blade has brought a considerable increase in its cost. Repair and overhaul of service stressed single crystal turbine components is an economic necessity for life cycle cost reduction of engines since the cost associated with replacement is significantly higher than its counterpart polycrystalline components. This paper will first review the recently reported research in developing repair technologies used for DS and SX components. These reported repair techniques repair the crack or defect while at the same time ensuring that the mechanical properties do not deteriorate and, more importantly, that the single-crystal microstructure is not jeopardized. It will then be followed by a brief overview of the research conducted and initiated by the authors in the area of repair of single crystal alloys.

PAPER 41B.3 — 9:20

PROGNOSIS AND MAINTENANCE MANAGEMENT SYSTEM FOR APPLICATIONS TO AIRCRAFT ENGINES

P. LI, R. THAMBURAJ, Advanced Materials and Energy Systems, Orenda Aerospace Corporation, Mississauga, Ontario, Canada and

P.C. PATNAIK, NRC-IAR Structures, Materials and Propulsion Laboratory, Ottawa, Ontario, Canada

An effective prognosis system for aircraft engines may involve the application of a wide range of technologies and methodologies, which may include:

- On-line, realtime and in-situ nondestructive inspection/detection/sensing
- Aircraft/engine instrumentation
- Airborne data recording system
- Advanced signal filtration

- Data compression
- On line engine health monitoring
- On line engine component life usage monitoring
- Mission severity analysis algorithm based on life prediction and damage tolerance analysis models
- Life assessment methodologies
- Optimized repair/overhaul/maintenance planning
- Optimization of mission assignment and homogeneous life usage
- Web-enabled information delivery and sharing system
- Decision making logistics

This presentation will demonstrate some efforts that Orenda has accomplished over the last decade in collaboration with the Institute for Aerospace Research of National Research Council Canada and the Department of National Defense. The presentation will focus on the following projects:

- Automated Eddy Current Inspection of compressor disks and spacers
- High temperature strain gauging techniques
- Airborne data recording system
- Development of mission severity analysis algorithms based on life consumption
- Development and application of life assessment methodologies
- Application of advanced damage tolerance analysis to aircraft engine components
- Application of a web-enabled information sharing system to gas turbine usage and maintenance monitoring
- A proposal on the development of a complete and web-enabled prognosis and reliability centered maintenance

system including built-in engine health monitoring, life usage monitoring, optimized repair/overhaul/maintenance planning, optimization of mission assignment and homogeneous life usage, and decision making logistics

The exercise of the above mentioned projects show the readiness of the state-of-the-art technologies and methodologies for the development of such a proposed prognosis, maintenance and usage optimization system for not only the newly developed aircraft but also the legacy and aged aircraft in both military and commercial airline applications.

PAPER 41B.4 — 9:45

DEVELOPMENT OF ENGINE LIFE CYCLE MANAGEMENT TECHNOLOGIES AT NRC-IAR

A. KOUL, LPT Inc.

Abstract not available

COFFEE BREAK — 10:10 – 10:40

PAPER 41B.5 — 10:40

CORROSION MODES IN AEROSPACE INDUSTRY

V.S. SASTRI, Sai Ram Consultants, Ottawa, Ontario, Canada

M. ELBOUJDAINI, Materials Technology Laboratory, CANMET, Ottawa, Ontario, Canada and

J.R. PERUMAREDDI, Chemistry Department, Florida Atlantic University

Economics of corrosion, the corrosion modes and causes, corrosion control methods to combat corrosion, along with a summary of issues and their implementation in the aerospace industry are briefly discussed.

PAPER 41B.6 — 11:05

AN INVESTIGATION ON CORROSION-ENHANCED EROSION BEHAVIOR

B.T. LU, J.L. LUO and J.F. LU, Chemical and Materials Engineering, University of Alberta, Edmonton, Alberta, Canada

The present paper investigates the chemo-mechanical effect in slurry-erosion corrosion process of carbon steel to understand the synergistic mechanism due to interaction of chemical and mechanical factors. The erosion-corrosion tests were conducted with A1045 steel in slurries comprising tap water and silica sand. Various heat treatments were adopted to achieve different hardness in the test material. The chemo-mechanical effect is evaluated in line with the correlation between the degradation of hardness in the surface layer and anodic current density. During the erosion-corrosion tests, various anodic currents were applied to find the relation between the anodic dissolution rate and erosion rate. The experimental results indicate that the hardness decreased with increasing anodic dissolution. Based on the fact that pure mechanical erosion rate increased with decreasing hardness, this result suggests that the corrosion-induced degradation of mechanical property is a mechanism of corrosion-enhanced erosion. This theoretical prediction is verified by erosion-corrosion experimental results.

PAPER 41B.7 — 11:30

MODELING OF STRESSES INDUCED BY OXIDATION PROCESS

A. M. LIMARGA, D. S. WILKINSON and G. C. WEATHERLY, Materials Science and Engineering, McMaster University, Hamilton, Ontario, Canada

Competition between stress generation and relaxation mechanisms during the oxidation process has been observed. However, the nature of the intrinsic growth stress in thermally grown scales is not well understood. In this talk, we will propose a conceptual model to calculate the intrinsic growth stress based on the analysis of stress-driven diffusional process of oxygen ions along the oxide grain boundary. The calculated stress, which is considered to originate from the constrained lateral expansion of the oxide, is in agreement with a range of experimental observations.