TUESDAY, AUGUST 24, 2004, P.M.

SESSION 28: SECOND INTERNATIONAL SYMPOSIUM ON AEROSPACE MATERIALS AND MANUFACTURING: DEVELOPMENT TESTING AND LIFE CYCLE ISSUES - HONORING WILLIAM WALLACE

CORROSION AND REPAIR TECHNOLOGIES FOR AEROSPACE MATERIALS
Sponsor: Materials Performance and Integrity Section, The Metallurgical Society of CIM
Room: 206
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 28.1 — 14:00
EFFECT OF GROWTH VELOCITY ON DEVELOPMENT OF PREFERRED ORIENTATIONS IN DIRECTIONALLY SOLIDIFIED TIAL-2MO-2NB
T.R. BIELER, Chemical Engineering and Materials Science, Michigan State University, East Lansing, Michigan, U.S.A.
D.Y. SEO, NRC-Institute for Aerospace Research, Structure, Materials and Propulsion Laboratory, Ottawa, Ontario, Canada
H. SAARI and J. BEDDOES, Mechanical and Aerospace Engineering, Carleton University, Ottawa, Ontario, Canada

Prior work on effects of lamellar orientation on creep rates and other mechanical properties have shown that having lamellae parallel to the tensile axis provides optimal creep resistance and good strength. Consequently, a directional solidification system was used to examine the effect of solidification rate on the development of crystals with lamellae parallel to the growth direction. The nominal chemical composition of TiAl ingots was Ti-46Al-2Mo-2Nb (at%) and the ingots were 20 mm in diameter and 180 mm long. The master alloy bars were placed in a high purity yttria mold on a copper chill plate and raised into the hot zone of a Bridgman furnace. The alloys were melted and then directionally solidified at withdrawal rates of 4, 8, and 12 mm/min. As-cast specimens were sectioned at positions of 4, 22, 66, 111, and 155 mm from the bottom of the ingot to evaluate microstructure and crystallographic texture as a function of distance from the bottom of the ingot. The directionally solidified microstructure consists of continuous columnar grains with fully lamellar structure, a network morphology of primary β, yttria particles, and interlocked columnar boundaries. For all three ingots, the texture at 4 mm shows many peaks, with isolated strong peaks, and a slight tendency toward <111> plane normals within about 20° of the cylindrical axis. At 155 mm, all specimens showed substantially stronger clustering of <111> orientations near the cylinder axis, with the strongest clustering of poles occurring for the 8 and 12 mm/min specimens. Analysis of diffraction peaks indicates that strongly compressive residual stresses in the radial direction are present in the casting. The combined microscopy and texture analysis provides more complete understanding of the processes of directional solidification of TiAl alloys.

PAPER 28.2 — 14:25
EFFECT OF PARTICLE SIZE ON THE LOW CYCLE FATIGUE LIFE OF DISCONTINUOUSLY REINFORCED MMCS
Q. ZHANG and D.L. CHEN, Department of Mechanical and Industrial Engineering, Ryerson University, Toronto, Ontario, Canada

The effect of the particle size on the low cycle fatigue (LCF) life of discontinuously reinforced metal matrix composites (DR-MMCs) has been widely studied. However, how the particle size affects the LCF life of DR-MMCs quantitatively is still lacking. The aim of this investigation is, therefore, to present an analytical model connecting the LCF life with the particle size. This model, based on the enhanced dislocation density in the matrix and the load bearing effect of particles, showed that a decreasing particle size resulted in a longer fatigue life, and the results predicted were in agreement with the experimental data.

PAPER 28.3 — 14:50
INTRODUCING COMPRESSIVE RESIDUAL STRESS ON METAL SURFACES BY IRRADIATING ULTRASONIC WAVE IN LIQUID.
M. NAKAGAWA, T. WATANABE and K. KIMAPONG, Niigata University, Niigata, Japan

Ultrasonic wave was irradiated on metal surface in water to introduce compressive residual stress. The ultrasonic wave that was oscillated with 19.5 kHz ultrasonic transducer and amplified with a step type horn was irradiated. Slight

plastic deformation occurred at the surface region of pure metal such as Cu and compressive residual stress was introduced. It seemed that the plastically deformed depth from the metal surface corresponded approximately to the depth of introduced residual stress. The higher compressive residual stress could be introduced into the surface of Cu-Zn brass and SUS304 stainless steel because work-hardening was simultaneously induced to those alloys. Furthermore, since martensitic transformation was induced by the plastic deformation in the case of SUS304, the compressive residual stress could be introduced more deeply into the surface region. The residual stress of SUS304 reached to the maximum value of 574 MPa by irradiating for 5min.

COFFEE BREAK — 15:15 – 15:45

PAPER 28.4 — 15:45

SUPERPLASTICITY AND ITS APPLICATION OF ULTRA-FINE-GRAINED TITANIUM ALLOYS OBTAINED THROUGH PROTIUM TREATMENT

H. YOSHIMURA, J. NAKAHIGASHI, K. TAKAHATA, Fukuyama University

Studies of a protium treatment for grain refinement of $\alpha + \beta$ type titanium alloy are reviewed and recent experimental results are introduced. Protium treatment consists of the following three processes: (1) protium absorption, (2) martensitic transformation and hot working, and (3) final treatment for protium desorption and recrystallization. A combination of these processes results in the ultra-fine grains of 0.3 to 0.5 μm in diameter with high angle boundaries. The ultra-fine-grained material exhibits superplastic elongation of over 9000%. Superplastic forming was successfully used to fabricate a denture base. These materials may be widely applicable as biomaterials in various medical industries.

PAPER 28.5 — 16:10

ELECTRON BEAM FREEFORMING

M. BROCHU, S. GIRARD, M. JAHAZI, NRC - Institute for Aerospace Research, Advanced Manufacturing Technology Centre, Ottawa, Ontario, Canada

This paper describes the advantages/disadvantages of electron beam freeforming using two different types of filler metal: (1) brazing paste and (2) solid wire. Sound buildups were obtained from both filler metal. The freeforms produced with the brazing paste showed a certain level of porosity, which was reduced by successive melting. In comparison, the solid wire buildup was practically free of pore. When compared with the solid wire filler, the brazing paste produced narrower buildups but a larger scattering of the width.

PAPER 28.6 — 16:35

VIBRATION DAMPING MATERIAL EMPLOYING MAGNETIC SHAPE MEMORY ALLOYS

R. HAM-SU, J.P. HEALEY, R. UNDERHILL, S.P. FARRELL, L.M. CHENG, C.V. HYATT, Defence R&D Canada-Atlantic, Dartmouth, Nova Scotia, Canada
J. CHEN and M.A. GHARGHOURI, Mining and Metallurgical Engineering, Dalhousie University

Magnetic shape memory alloys (MSMA's) are a class of materials where magnetic energy can be converted into mechanical energy and vice versa. NiMnGa-based MSMA's have attained magnetic field induced strains up to approximately 10% and have a relatively wide operating temperature range, from well below 0oC to above RT, making them very attractive for a variety of applications. However, these materials also suffer from low toughness. Using these materials in a composite could mitigate this shortcoming, and also overcome limits imposed by inertia and eddy current losses. In this work, we describe the manufacture and characterization of such composites. Composites with 30% by volume MSMA were fabricated under a magnetic field resulting in anisotropic magnetic properties. Damping properties were evaluated by dynamic mechanical analysis.