

**The 9th International Conference on  
MULTIAXIAL FATIGUE & FRACTURE (ICMFF9)**

Parma (Italy), 7 – 9 June, 2010  
University of Parma - Via Università, 12 (in the city centre)

**MONDAY 7th June, 2010**

08.00-09.00 Registration

**09.10-09.30 Opening Ceremony (room: Aula Magna)**

**09.30-10.30 Introductory Plenary Lectures (room: Aula Magna)**

Chairperson: Darrell SOCIE, Urbana (USA)

09.30-10.00 Material Influence on Multiaxial Fatigue Response  
C.M. Sonsino (page 19)

10.00-10.30 Multiaxial Fatigue Modeling and Some Simple Approximations  
A. Fatemi, N. Shamsaei (page 17)

10.30-11.00 Refreshment (coffee, drinks, etc.)

**11.00-12.25 Parallel Sessions A1, B1 and C1 (see next pages)**

12.25-14.15 Lunch

**14.15-15.40 Parallel Sessions A2, B2 and C2 (see next pages)**

15.40-16.10 Refreshment (coffee, drinks, etc.)

**16.10-17.30 Parallel Sessions A3, B3 and C3 (see next pages)**

**17.40-18.10 ICMFF Scientific Committee Meeting (room: Aula Magna):  
Confirmation of the venue of ICMFF10 (Kyoto, Japan)**

**19.30-21.00 Welcome Party (in the main Hall of the University)**

## **PARALLEL SESSION A1 - room: Aula Magna**

**7th June, 2010, time 11.00-12.25**

Chairperson: Michael VORMWALD, Darmstadt (Germany)

- |       |   |         |
|-------|---|---------|
| 11.00 | A strain energy based criterion for multiaxial fatigue failure<br><u>F. Ellyin</u> (Invited Paper)  | page 34 |
| 11.25 | A damage mechanics approach to multiaxial fatigue<br>Andrea Carpinteri, <u>R. Brighenti</u> , A. Spagnoli, S. Vantadori   | 121     |
| 11.50 | Fatigue assessment of smooth metallic specimens using a simplified multiaxial criterion based on the critical plane approach<br>Andrea Carpinteri, R. Brighenti, A. Spagnoli, <u>S. Vantadori</u> | 122     |
| 12.10 | On the generation of a loading history with zero mean for structures subjected to multiaxial variable stresses<br><u>B. Kocer</u> , Y. Yazicioglu, S. Dag   | 42      |

## **PARALLEL SESSION B1 - room: Aula dei Filosofi**

**7th June, 2010, time 11.00-12.25**

Chairperson: Roger RABB, Vaasa (Finland)

- |       |   |         |
|-------|---|---------|
| 11.00 | A general multiaxial method to estimate the local elastic-plastic behavior from a purely elastic solution<br>R.J. McDonald, <u>D.F. Socie</u> (Invited Paper)               | page 26 |
| 11.25 | Fracture of aluminium alloy 2024 under triaxial loading<br>M. Mostafavi, D.J. Smith, <u>M.J. Pavier</u>   | 84      |
| 11.50 | Experimental investigation of stress-strain curves in a cast TRIP steel under biaxial planar loading<br><u>K. Nagel</u> , D. Kulawinski, S. Henkel, H. Biermann, P. Huebner | 44      |
| 12.10 | Interface and bulk fracture modes and strengths determined by laser-induced stress pulses<br><u>P. Hess</u> , A.M. Lomonosov  | 40      |

## **PARALLEL SESSION C1 - room: Aula dei Cavalieri**

**7th June, 2010, time 11.25-12.25**

Chairperson: Veronique DOQUET, Palaiseau (France)

- |       |   |         |
|-------|---|---------|
| 11.25 | Strength degradation analysis of notched concrete beam based on numerical simulation of bending test under sequential loads<br><u>Z. Shi</u> , Y. Nakamura, M. Nakano | page 64 |
| 11.45 | A study of biaxial fatigue behavior of a synthetic rubber<br><u>J.L. Poisson</u> , F. Lacroix, S. Meo, G. Berton, N. Ranganathan                                      | 77      |
| 12.05 | Multiaxial fatigue resistance in thermoplastics and correlation to cyclic behavior<br><u>S. Castagnet</u> , Y. Nadot, A. Berrehili, J.C. Grandidier                   | 118     |

## **PARALLEL SESSION A2 - room: Aula Magna**

**7th June, 2010, time 14.15-15.40**

Chairperson: Martyn J. PAVIER, Bristol (UK)

14.15	IDD (integration of damage differentials): general representation <u>S.H. Stefanov</u> (Invited Paper)	page 32
14.40	Multiaxial fatigue criteria applied to medium speed diesel engines <u>R. Rabb</u> , C. Loennqvist, J. Kaas	50
15.00	Notch optimization under multiaxial loading M. Guagliano, A. Bernasconi, <u>R. Ghelichi</u>	60
15.20	Improvements in the algorithms for the determination of the shear stress components in critical plane class fatigue criteria <u>G. Petrucci</u>	72

## **PARALLEL SESSION B2 - room: Aula dei Filosofi**

**7th June, 2010, time 14.15-15.40**

Chairperson: Jaime DOMINGUEZ, Seville (Spain)

14.15	A new test method for obtaining stable mode III crack growth under RCF condition <u>S. Beretta</u> , S. Foletti, M.G. Tarantino, K. Valiullin (Invited Paper)	page 35
14.40	Effects of biaxial loading on inclined surface cracks behavior <u>V.N. Shlyannikov</u> , A.V. Tumanov, S.Yu. Kislova	68
15.00	Specimen for fracture characterization of material under biaxial stress fields <u>G.P. Pucillo</u> , M. Grasso, F. Penta, P. Pinto	103
15.20	BEM simulation and experimental test of a FML full scale aeronautic panel undergoing biaxial static and fatigue load E. Armentani, V. Ascione, <u>R. Citarella</u> , R. Sepe	70

## **PARALLEL SESSION C2 - room: Aula dei Cavalieri**

**7th June, 2010, time 14.40-15.40**

Chairperson: Roberto BRIGHENTI, Parma (Italy)

14.40	A biaxial endurance criterion developed within the linear elastic fracture mechanic frameworks <u>R. de Moura Pinho</u> , S. Pommier, C. Mary, A. Longuet, F. Vogel	page 105
15.00	A comparison of fatigue characteristics of structural steels measured by means of classical and miniature test samples J. Volak, <u>V. Mentl</u>	78
15.20	Numerical modelling of fatigue damage in gears tooth root <u>M. Franulovic</u> , R. Basan, R. Kunc, I. Prebil	93

### **PARALLEL SESSION A3 - room: Aula Magna**

**7th June, 2010, time 16.10-17.30**

Chairperson: John YATES, Sheffield (UK)

- 16.10 Low-cycle fatigue behaviour and microstructure development of copper and alpha-brass under planar biaxial loading  
S. Henkel, J. Fischer, L. Balogh, T. Ungar, M. Hermsdorf, H. Biermann page 82
- 16.30 Investigation of multiaxial fatigue in the prospect of turbine disc applications: Part I – Experimental setups and results  
V. Bonnard, J.L. Chaboche, P. Gomez, P. Kanouté, D. Pacou, P. Paulmier 100
- 16.50 Investigation of multiaxial fatigue in the prospect of turbine disc applications: Part II – Fatigue criteria analysis and formulation of a new combined one  
V. Bonnard, J.L. Chaboche, H. Cherouali, P. Kanouté, E. Ostoja-Kuczynski, F. Vogel 101
- 17.10 Fatigue behaviour of laserbeam welded thin steel and aluminium sheets under multiaxial loading  
J. Wiebesiek, K. Stoerzel, T. Bruder, H. Kaufmann 43

### **PARALLEL SESSION B3 - room: Aula dei Filosofi**

**7th June, 2010, time 16.10-17.30**

Chairperson: R. SUNDER, Bangalore (India)

- 16.10 Multiaxial study of notched component of Sn-3.5Ag solder in creep-fatigue  
M. Nozaki, S. Zhang, M. Sakane, K. Kobayashi page 69
- 16.30 3D model for the evaluation of multiaxial fracture behavior of reinforced concrete members  
R. Cerioni, P. Bernardi, E. Michelini, A. Mordini 108
- 16.50 Damage nucleation in nuclear graphite under biaxial flexural loading  
M. Mostafavi, J. Duff, R. Delorme, T.J. Marrow 48
- 17.10 In-plane and out-of-plane crack-tip constraint effects under biaxial loading in plastic and creeping materials  
V.N. Shlyannikov, N.V. Boichenko, A.M. Tartygasheva 67

### **PARALLEL SESSION C3 - room: Aula dei Cavalieri**

**7th June, 2010, time 16.10-17.30**

Chairperson: Luca SUSMEL, Ferrara (Italy)

- 16.10 Is Miner's law valid for asphalt mixes?  
C. Weise, A. Blasl page 80
- 16.30 Multiaxial fracture model for weak fiber/matrix interface composite within the three bending fatigue test  
K.A. Khvostunkov, A.G. Shpenev 102
- 16.50 Study and 3D analysis of the drilling process influence on notched single crystal superalloy specimens  
R. Degeilh, V. Bonnard, D. Pacou 98
- 17.10 A study of the stability of sharp notches in the orthotropic heterogeneous media  
T. Profant, J. Klusak, M. Kotoul 106

## **TUESDAY 8th June, 2010**

### **09.00-09.30 Plenary Lecture (room: Aula Magna)**

Chairperson: Michael BROWN, Sheffield (UK)

Scale Levels of Crack Closure Effects and Simulation of Fatigue Cracking  
of Al-based Sheet Materials Subjected to Biaxial Cyclic Loads

A.A. Shanyavskiy (page 18)

### **09.35-10.35 Parallel Sessions A4, B4 and C4 (see next pages)**

10.35-11.00 Refreshment (coffee, drinks, etc.)

### **11.00-12.25 Parallel Sessions A5, B5 and C5 (see next pages)**

12.25-14.15 Lunch

### **14.15-15.40 Parallel Sessions A6 and B6 (see next pages)**

15.40-16.10 Refreshment (coffee, drinks, etc.)

### **16.10-17.30 Parallel Sessions A7 and B7 (see next pages)**

Circolo di Lettura e Conversazione (Reading and Social Club) - Room San Paolo  
in the centre of Parma (**Via Melloni, 4/A, between Pilotta and Piazza Duomo**) :

**19.30-20.30 Opera Concert (Italian Opera Pieces and Traditional Songs from Naples)**

**20.30-22.30 Conference Dinner**

**PARALLEL SESSION A4 - room: Aula Magna**

**8th June, 2010, time 09.35-10.35**

Chairperson: Michael BROWN, Sheffield (UK)

- 09.35 Fatigue crack propagation under torsional spectrum load of a helicopter tail rotor shaft after ballistic damage  
A. Manes, L. Giudici, M. Giglio page 47
- 09.55 Biaxial fatigue of aluminum alloy 1100  
E.U. Lee, R. Taylor 62
- 10.15 Fatigue crack growth analysis under mixed mode loading  
Slobodanka Boljanovic, S. Maksimovic 83

**PARALLEL SESSION B4 - room: Aula dei Filosofi**

**8th June, 2010, time 09.35-10.35**

Chairperson: Manuel de FREITAS, Lisbon (Portugal)

- 09.35 A strategy for the estimation of the fatigue life of notched components under random multiaxial fatigue  
G. Cailletaud, T. Herbland, B. Melnikov, A. Musienko, S. Quilici page 110
- 09.55 A model for biaxial fatigue limits  
A. Navarro, C. Vallellano, V. Chaves, C. Madrigal 111
- 10.15 Fatigue strength of welded joints under multiaxial loading in terms of local strain energy density  
F. Berto, P. Lazzarin 113

**PARALLEL SESSION C4 - room: Aula dei Cavalieri**

**8th June, 2010, time 09.35-10.35**

Chairperson: Hamid JAHED, Waterloo (Canada)

- 09.35 A study on notch fatigue based on multiaxial gradient dependent fatigue limit criterion  
M.G. Tarantino, S. Foletti, I.V. Papadopoulos page 52
- 09.55 Analytical and numerical modelling of the Swift effect in elastoplastic torsion  
L. Gambirasio, P. Chiodi, E. Rizzi 119
- 10.15 Multiaxial fatigue damage modeling of TiAl4V alloy  
A.K. Marmi, A.M. Habraken, L. Duchene 85

## **PARALLEL SESSION A5 - room: Aula Magna**

**8th June, 2010, time 11.00-12.25**

Chairperson: Stefano BERETTA, Milan (Italy)

11.00	A new solution for 3D crack extension based on linear elastic stress fields <u>Y.H. Tai</u> , M.W. Brown, J.R. Yates	(Invited Paper)	page 27
11.25	Life estimation in specimens with stress gradient: notches and fretting fatigue C. Navarro, J. Vazquez, <u>J. Domínguez</u>		89
11.45	Notch effect on torsional fatigue of austenitic stainless steel <u>C. Ohkawa</u> , I. Ohkawa		54
12.05	The influence of combined loading on fatigue crack growth from small defects <u>M. Endo</u> , A.J. McEvily		92

## **PARALLEL SESSION B5 - room: Aula dei Filosofi**

**8th June, 2010, time 11.00-12.25**

Chairperson: Hiroshi NAKAMURA, Yokohama (Japan)

11.00	Fatigue crack growth analysis of structural components – the UniGrow two-parameter driving force model S. Mikheevskiy, <u>G. Glinka</u> , D. Algera	(Invited Paper)	page 28
11.25	Multiaxial HCF and LCF constraints in topology optimization <u>M. Mrzyglod</u>		114
11.45	On the use of the Modified Wöhler Curve Method applied along with the Reference Radius Concept to perform the multiaxial fatigue assessment of welded joints L. Susmel, C.M. Sonsino, <u>R. Tovo</u>		120
12.05	The effect of mean stress on tension-torsion high-cycle fatigue failure of 2A12-T4 aluminum alloy <u>X. Shi</u> , J. Zhang, R. Bao, B. Fei		81

## **PARALLEL SESSION C5 - room: Aula dei Cavalieri**

**8th June, 2010, time 11.00-12.25**

Chairperson: Georges CAILLETAUD, Paris (France)

11.00	Fatigue life of specimens with round and rectangular cross-sections under out-of-phase bending and torsional loading D. Rozumek, <u>Z. Marciniak</u> , E. Macha	(Invited Paper)	page 25
11.25	Low cycle lifetime assessment of Al2024 alloy <u>O. Kintzel</u> , S. Khan, J. Mosler		88
11.45	History effects in fatigue under variable amplitude loading mode I conditions in a 316L stainless steel <u>F. Fremy</u> , S. Pommier, E. Galenne		91
12.05	Three-dimensional analysis of dissipated energy in fatigue crack growth <u>C.M. Davis</u> , J.S. Daily		104

**PARALLEL SESSION A6 - room: Aula Magna**

**8th June, 2010, time 14.15-15.40**

Chairperson: Alfredo NAVARRO, Seville (Spain)

14.15	Estimating the notch and mean stress effect in fatigue through the degree of multi-axiality of the local elasto-plastic stress/strain fields <u>L. Susmel</u> , B. Atzori, G. Meneghetti, D. Taylor (Invited Paper)	page 29
14.40	3D shear-mode fatigue crack growth in maraging steel <u>V. Doquet</u> , Q.H. Bui, L. Alves, G. Bertolino	46
15.00	Fatigue lifetime assessment of notched components under multi-axial variable amplitude loading based on a short crack growth concept O. Hertel, <u>M. Vormwald</u>	65
15.20	Effect of interference of crack faces on shear-mode threshold for small fatigue cracks in a bearing steel <u>H. Matsunaga</u>	79

**PARALLEL SESSION B6 - room: Aula dei Filosofi**

**8th June, 2010, time 14.15-15.40**

Chairperson: Fernand ELLYIN, Vancouver (Canada)

14.15	Material dependence of multi-axial low cycle fatigue damage under non-proportional loading <u>T. Itoh</u> , T. Yang (Invited Paper)	page 31
14.40	A brief introduction to coiled springs as a power source <u>Les P. Pook</u>	39
15.00	Multi-axial deformation and fatigue behaviors under discriminating strain paths N. Shamsaei, <u>A. Fatemi</u> , D.F. Socie	55
15.20	Mean stress effect during cyclic stress/straining of 42CrMo4 structural steel <u>L. Reis</u> , B. Li, M. de Freitas	71

**PARALLEL SESSION A7 - room: Aula Magna**

**8th June, 2010, time 16.10-17.30**

Chairperson: Hisao MATSUNAGA, Fukuoka (Japan)

16.10	The influence of static normal stress on shear capacity of bonded high strength steel interfaces <u>S. Renvall</u> , A. Oinonen, G. Marquis	page 53
16.30	Inelastic analysis of power plant components under transient thermal environment <u>K. Naumenko</u> , A. Kutschke, Y. Kostenko, Th. Rudolf	56
16.50	An extrapolation method applied to a constitutive material model to recalculate creep fatigue experiments P. Wang, <u>M. Lyschik</u> , A. Scholz, C. Berger	61
17.10	Assessment of critical defects in a PSA pressure vessel subjected to cyclical loading using BS-7910 procedures <u>H.M. Sant'Anna</u> , M.F. Leal	107

**PARALLEL SESSION B7 - room: Aula dei Filosofi**

**8th June, 2010, time 16.10-17.30**

Chairperson: Gregory GLINKA, Waterloo (Canada)

16.10	On the formulation of non-local multiaxial high-cycle fatigue models based on the theory of critical distances <u>F.C. Castro</u> , J.A. Araujo, E.N. Mamiya	page 73
16.30	An alternative measure for the shear stress amplitude in critical plane based multiaxial fatigue models A.P. Dantas, <u>J.A. Araujo</u> , E.N. Mamiya, F.C. Comes, J.L.A. Ferreria	86
16.50	Fatigue crack growth under flight spectrum loading with superposed fuselage cabin pressure <u>R. Sunder</u>	97
17.10	Benefit of taking account of the yield-point phenomenon in a multiaxial constitutive model of cyclic plasticity <u>A. Zerovnik</u> , R. Kunc, I. Prebil	90

## **WEDNESDAY 9th June, 2010**

### **09.00-09.30 Plenary Lecture (room: Aula Magna)**

Chairperson: Gary MARQUIS, Helsinki (Finland)

Notch Effect on Multiaxial Low Cycle Fatigue  
M. Sakane, S. Zhang, K. TaeJoon (page 20)

### **09.35-10.35 Parallel Sessions A8, B8 and C8 (see next pages)**

10.35-11.00 Refreshment (coffee, drinks, etc.)

### **11.00-12.05 Parallel Sessions A9 and B9 (see next pages)**

### **12.10-12.45 Closing Lecture and Concluding Remarks (room: Aula Magna)**

Chairperson: Andrea CARPINTERI, Parma (Italy)

12.10 Current Trends in Multiaxial Fatigue Research and Assessment  
G. Marquis (page 21)

12.35 Concluding Remarks  
Les P. Pook

**PARALLEL SESSION A8 - room: Aula Magna**  
**9th June, 2010, time 09.35-10.35**

Chairperson: Gary MARQUIS, Helsinki (Finland)

- 09.35 Mean strain effect on multiaxial fatigue behavior of Ti-6Al-4V under non-proportional loading  
M. Wu, T. Itoh, Y. Shimizu, H. Nakamura, M. Takanashi page 63
- 09.55 Effect of non-proportional multiaxial fatigue loading on micro crack initiation and propagation of Ti-6Al-4V  
H. Nakamura, M. Takanashi, T. Itoh, Y. Shimizu, M. Wu 76
- 10.15 Cyclic calculations and life estimation in thermomechanical fatigue  
F. Azzouz, G. Cailletaud, J.L. Chaboche, E. Ostoja-Kuczynski, S. Quilici 112

**PARALLEL SESSION B8 - room: Aula dei Filosofi**  
**9th June, 2010, time 09.35-10.35**

Chairperson: Thierry PALIN-LUC, Talence (France)

- 09.35 Fatigue assessment of crane rail welds by local concepts  
M. Euler, U. Kuhlmann page 117
- 09.55 Methodology for lifing turbine disk bores under multiaxial states of stress  
M.N. Menon, P.T. Kantzos, D.J. Greving 41
- 10.15 A multiaxial fatigue approach to estimate crack initiation and stress gradient effect in fretting  
R. Amargier, S. Fouvry, L. Chambon, C. Schwob, C. Poupon 45

**PARALLEL SESSION C8 - room: Aula dei Cavalieri**  
**9th June, 2010, time 09.35-10.35**

Chairperson: Valery SHLYANNIKOV, Kazan (Russia)

- 09.35 Phenomenological lifetime assessment for turbine housings of turbochargers  
F. Laengler, T. Mao, H. Aleksanoglu, A. Scholz page 51
- 09.55 On determination of bifurcation angle in V-notched Brazilian disc specimen under mixed mode loading  
A.R. Torabi, M.R. Ayatollahi 87
- 10.15 Multiaxial fatigue assessment for notched bars under non-proportional loading using integral stress approach  
E. Leidich, J. Vidner 99

**PARALLEL SESSION A9 - room: Aula Magna**

**9th June, 2010, time 11.00-12.05**

Chairperson: Masahiro ENDO, Fukuoka (Japan)

- 11.00 Multiaxial fatigue strength assessment of components treated by surface induction hardening (Invited Paper)  
T. Palin-Luc, D. Coupard, C. Dumas, P. Bristiel page 30
- 11.25 Life estimation of a composite structural component in a multi-axial stress state  
C. Colombo, L. Vergani 49
- 11.45 Multiaxial fatigue behavior of short-fiber reinforced thermoplastic roof bars  
B. Klimkeit, S. Bergamo, Y. Nadot, S. Castagnet, C. Dumas, A. Buter, J. Dreissig 116

**PARALLEL SESSION B9 - room: Aula dei Filosofi**

**9th June, 2010, time 11.00-12.05**

Chairperson: José Alexander ARAUJO, Brasilia (Brazil)

- 11.00 Fatigue damage accumulation in a structural steel (42CrMo4) subjected to axial/torsional bi-axial loadings (Invited Paper)  
M. de Freitas, L. Reis, B. Li page 33
- 11.25 An energy-based fatigue model for wrought magnesium alloy under multiaxial load  
J. Albinmousa, H. Jahed, S. Lambert 74
- 11.45 Cohesive zone model for the simulation of fatigue crack growth in adhesive joints under mixed mode I/II loading conditions  
F. Moroni, A. Pirondi 94

**12.10-12.45 Closing Lecture and Concluding Remarks - room: Aula Magna**

Chairperson: Andrea CARPINTERI, Parma (Italy)

- 12.10 Current Trends in Multiaxial Fatigue Research and Assessment  
G. Marquis page 21
- 12.35 Concluding Remarks  
Les P. Pook