TRIESTE

12 SEPTEMBER 2002

Durability and Life Extension

FE SIMULATION IN FRACTURE AND CRACK GROWTH

WORKSHOP INTRODUCTION AND OBJECTIVES

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State of the work

Main workshop objectives

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ZURICH 13-14 JUNE 2002 – DLE SESSIONS

A Brief Overview

FE issues related to Structural Integrity (Fracture, Fatigue, Creep)

Prof. Adib Becker

The main objectives of the previous workshop were:

1. to provide an overview of the current state of FE technology in applications related to structural integrity, particularly in **fracture**, **fatigue**, **creep** and **weld analysis**;
2. to provide a discussion forum to identify the need for FE benchmarks in structural integrity;
3. to identify specialist workshop topics in structural integrity.

A total of 14 presentations were delivered, each followed by an open discussion.

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A Brief Overview

The forum held during the workshop, addressed the discussion on;

Fracture

- – modelling crack closure
- – 3D crack models
- – 2D and 3D crack propagation laws
- – interaction of two or more cracks
- – crack propagation/re-meshing in commercial FE packages

Fatigue

- – modelling variable fatigue loads
- – choosing multiaxial fatigue criteria
- – specialist fatigue software

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A Brief Overview

Creep

– creep damage laws

– implementing damage in "user-subroutines"

– changing internal variables in FE software

– damage benchmarks

– user-friendliness of "user-subroutines"

– creep-fatigue interaction

Weld analysis

– development of weld benchmarks

– development of "Guidelines" and "Best Practice" on using FE in welds

– modelling residual stresses and comparison with experiment

– modelling weld interfaces (heat affected zone) and cracks in welds

– implementing FE solutions in weld design codes

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Introduction

This workshop is intended to allow a deeper insight to several topics related to FE simulation of fracture and crack growth still challenging several sectors;

- – SIF and N-SIF numerical evaluation
- – 2D and 3D crack modelling
- – crack initiation, propagation and merging in fatigue
- – final fracture simulation
- – remeshing

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Main Objectives

The main objectives of this workshop are therefore:

1. to identify the potentialities and the limitations of current FE methods and tools in FE fracture and crack growth simulations

2. to create the opportunity of a mutual sharing of experiences, either successful or unsuccessful, for increasing the degree of competence and awareness on the topic

3. to propose a set of actions to be adopted by the users an the SW developers to solve problems and to spread the adoption of FE simulations.

TRIESTE 12 SEPTEMBER 2002 – DLE SESSION

Session Schedule

9:00 – 9:30	**FE SIMULATION IN FRACTURE AND GROWTH: WORKSHOPS INTRODUCTION AND OBJECTIVES** N. Petrone – University of Padova, Dept. of Mechanical Engineering, ITALY.
9:30 – 10:00	**THREE DIMENSIONAL CRACK MODELLING: TECHNIQUES AND CONSIDERATIONS FROM THE ANALYSIS OF PIN-LOADED TUBULAR JOINTS** Dr. Richard J. Grant, NEWI – University of Wales, UK Dr. John Smart – University of Manchester, UK.
10:00 – 10:30	**EVALUATION OF STRESS INTENSITY FACTORS USING FINITE ELEMENTS** B. Zafosnik, Z. Ren, M. Ulbin, J. Flasker – University of Maribor, Faculty of Mechanical Engineering, SLOVENIA.
10:30 – 11:00	**Open Discussion**
11:00 – 11:30	**Coffee Break**
11:30 – 12:00	**EVALUATION OF FATIGUE LIFE BY MEANS OF THE CRACK TIP STRESS METHOD AFTER FINITE ELEMENT ANALYSIS** G. Meneghetti – University of Padova, Dept. of Mechanical Engineering, ITALY.
12:00 – 12:30	**CRACK PROPAGATION AND LIFE PREDICTION WITH A PARAMETRIZED MODEL WITH SAMCEF** P. Gonze, SONACA. Speaker: Mr. J. P. Delsemme, Samtech, LIEGI.
12:30 – 14:00	**Lunch**

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Session Schedule

14:00 – 15:30	SPACE FOR LATE PRESENTATION & OPEN DISCUSSION
15:30	**WORKSHOP CONCLUSIONS AND PLANNING FOR FUTURE WORKSHOPS** N. Petrone – University of Padova, Dept. of Mechanical Engineering, ITALY.

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Coordinators will be asked to contribute with any additional industry specific question they deem necessary, and RTD coordinators to concentrate on reviewing the generic questions, as well as any industry sectors they feel they can contribute to.

Please rate the issues in each area, in terms of both maturity (readiness for deployment), and priority (importance to your business), on a scale from 0-9 (0- low maturity/priority, 9 high)

	Maturity	Priority
Fatigue life prediction & assessment		
Fracture mechanics, crack assessment and residual strength prediction		
Damage/deterioration modelling and assessment		
Reliability and probabilistic analyses		
Creep and related time-dependent phenomena		
Buckling and post-buckling		
Composite materials - characterisation, modelling and assessment		
Modelling and assessment of residual stresses (due to welding, moulding, casting etc)		
Modelling and assessment of welds		

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Final Discussion

The main objectives of this workshop WERE :

1. to identify the potentialities and the limitations of current FE methods and tools in FE fracture and crack growth simulations

2. to create the opportunity of a mutual sharing of experiences, either successful or unsuccessful, for increasing the degree of competence and awareness on the topic

3. to propose a set of actions to be adopted by the users an the SW developers to solve problems and to spread the adoption of FE simulations

4. *create the background and the awareness for the possible definition of a Project within Framework VI*

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Concluding Remarks - <u>OBJECTIVE 1</u>

OBJECTIVE 1: …to identify the <u>potentialities</u> and the <u>limitations</u> of current FE methods and tools in FE fracture and crack growth simulations….

Open problems from previous meeting on FRACTURE AND CRACK GROWTH FE SIMULATION

- – SIF and N-SIF numerical evaluation
- – 2D and 3D crack modelling
- – crack initiation, propagation and merging in fatigue
- – final fracture simulation
- – remeshing

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Concluding Remarks - <u>OBJECTIVE 1</u>

Four presentation were given:

- two presentation focused on 2D crack modelling application.

- methods for simplified SIF evaluation based on VCE and CTSM were presented.
- VCE allows for mixed mode analysis and crack kinking predictions by means of special crack tip elements
- CTSM allows for linear elastic analysis with coarse mesh after calibration, mode 1.

- one presentation focused on 3D crack modelling.

- given a crack trajectory, the crack twist and tilt can be predicted on a particular tubular-pin joint. The method can be extended to complex loads and components

- one presentation focused on aerospace components crack propagation with customized SW tool.

- given a rivet line, the crack is simulated by progressive release of special elements and allow for integration of life to failure.

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Concluding Remarks - <u>OBJECTIVE 1</u>

Open problems from previous meeting on FRACTURE AND CRACK GROWTH FE SIMULATION

- SIF and N-SIF numerical evaluation
- 2D and 3D crack modelling
  - *state of the art is available at research centres (companies-universities) but state of practice is still behind.*
- crack initiation, propagation and merging in fatigue
  - *need of tools for crack direction and crack growth rate estimation.*
  - *which is the upper limit: are we designing for safety or are we trying to describe the phenomenon?*
  - *what is the real industry-users demand on that?*
- final fracture simulation
  - *what is the real industry-users demand on that?*
  - *examples from power nuclear plants may demand.*
  - *special event (crash, brittle failure..) may demand.*

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Concluding Remarks - <u>OBJECTIVE 1</u>

- remeshing
  - *there is a real need of meshing and remeshing tools specialised for crack propagation*
  - *at which level these tools shall develop? CAD model, mesh level? General opinion was …at mesh level for very complex components.*
  - *comparison with MultiPhysics tools seems not suitable.*
  - *possible hybrid tools for two stage solution: 1st crack trajectory, 2nd SIF evaluation. Is this mix too complex?*
  - *who has to start up the development loop?: users, SW developers, researchers ?*
  - *which are the occasions and procedures for contacts between actors*
  - *………………………*

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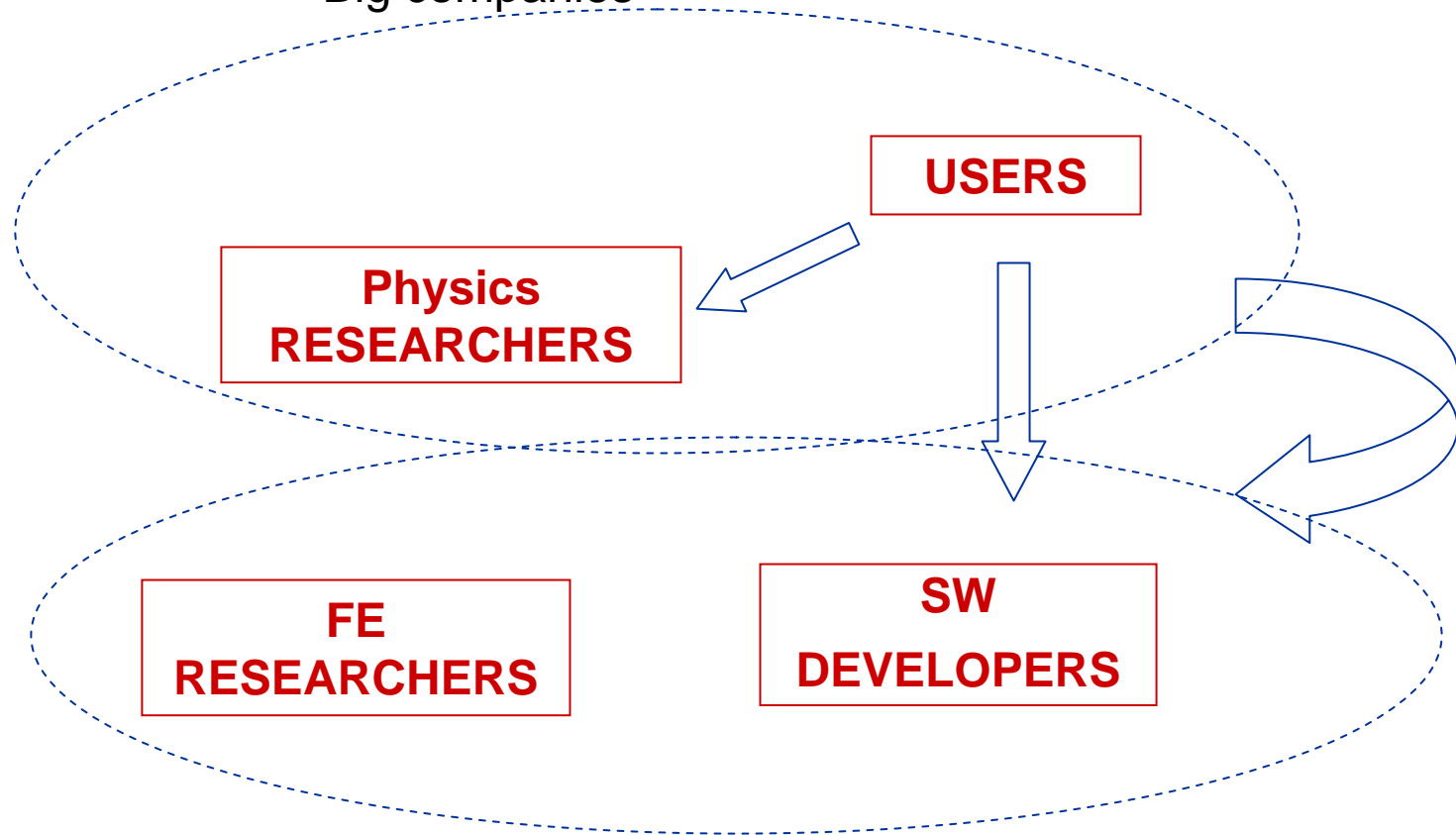**TRIESTE 12 SEPTEMBER 2002 – DLE SESSION**

Concluding Remarks - <u>OBJECTIVE 2</u>

OBJECTIVE 2: "… to create the opportunity of a mutual sharing of experiences, either successful or unsuccessful, for increasing the degree of competence and awareness on the topic …"

Successful discussion stimulated by presentations contents, speakers and audience.

USERS

RESEARCHERS

SW DEVELOPERS

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– Big companies

USERS

Physics RESEARCHERS

FE RESEARCHERS

SW DEVELOPERS

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Concluding Remarks - <u>OBJECTIVE 3 & 4</u>

OBJECTIVE 3: "…to propose a set of actions to be adopted by the users an the SW developers to solve problems and to spread the adoption of FE simulations …"

SW developers should consider these suggestions and liaise with industry and researchers for routinely perform crack propagation analysis

OBJECTIVE 4: "… create the background and the awareness for the possible definition of a Project within Framework VI …"

Common interest on the definition of a research project that may aim to transfer experiences from the component scale to the micro and nano scale, justifying the research and the participation of SW developers too.

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