LCF and TMF crack growth in cast nickel-base superalloy

CHRISTIAN BUSSE
SOLID MECHANICS

- ***Agenda***
- *Project infos*
- *Overview*
- *Spring activities*
- *Teaching*
- *Ph.D. courses*
- *Future work*

Agenda

- Project informations
- Overview
- Spring activities
- Teaching
- Ph.D. courses
- Future work

- *Agenda*
- ***Project infos***
- *Overview*
- *Spring activities*
- *Teaching*
- *Ph.D. courses*
- *Future work*

Project informations

Goals

- Reaserach programme: KME – Konsortiet för Materialteknik för termiska Energieprocesser
- The goals of this KME project (KME 702) are:
  - investigate and model LCF and TMF crack propagation in cast nickel-based superalloys with special focus on STAL15
  - Different effects on the crack propagation like hold times, creep and at some point aging are investigated
  - Accounting of elastic and plastic anisotropy, as well as tension/compression asymmetry
  - Applicability of LEFM is to be investigated

- *Agenda*
- ***Project infos***
- *Overview*
- *Spring activities*
- *Teaching*
- *Ph.D. courses*
- *Future work*

Project informations

Work allocation

The work will be:

- Theoretical (in order to understand the material model and its implementation as well as the handling of the crack growth)

- Experimental (in order to verify the simulated results by laboratory tests and to give further insight in the material behavior under TMF loading)

- *Agenda*
- ***Project infos***
- *Overview*
- *Spring activities*
- *Teaching*
- *Ph.D. courses*
- *Future work*

Project informations

Participants

- Project supervisor: Kjell Simonsson
- Assistant supervisor I : Daniel Leidermark
- Assistant supervisor II : Johan Moverare
- Assistant supervisor III: David Gustafsson (SiT)
- Ph.D. advisors: Mikael Segersäll (LiU)

  Patrik Rasmusson (SiT)

  Per Almroth (SiT)

  Frans Palmert (SiT)

  Björn Sjödin (SiT)

  Magnus Hasselqvist (SiT)

  Håkan Brodin (SiT)

- *Agenda*
- *Project infos*
- ***Overview***
- *Spring activities*
- *Teaching*
- *Ph.D. courses*
- *Future work*

Overview – Performed work

- Background studies on LCF crack propagation simulations on IN718 using FRAMC3D in master thesis
- Method development for TMF crack growth simulations on IN792 using FRANC3D

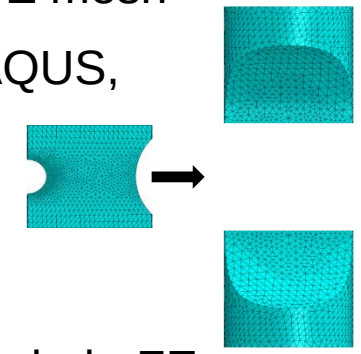
- *Agenda*
- *Project infos*
- ***Overview***
- *Spring activities*
- *Teaching*
- *Ph.D. courses*
- *Future work*

Overview – FRANC3D

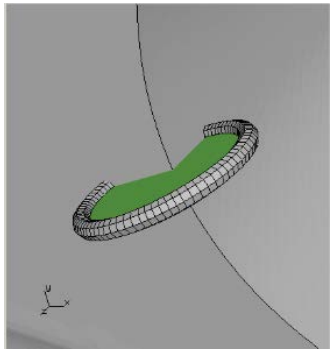
Introduction

Main Features:

- Crack growth software
- Supports automated crack growth in FE mesh
- Uses power of external FE code (ABAQUS, ANSYS, NASTRAN)
- Cracks are given in templates
- Possibility to extract sub-model



Only a local domain is remeshed, but whole FE-model is used for stress calculation

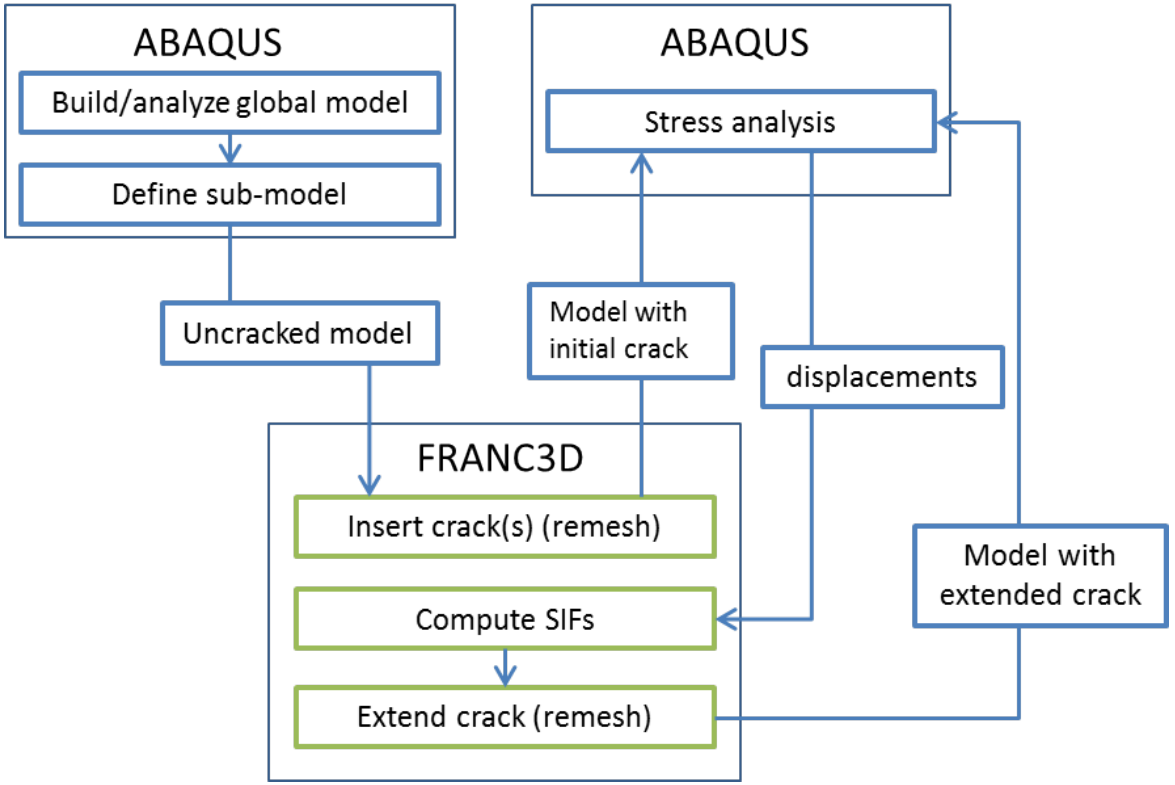


- *Agenda*
- *Project infos*
- ***Overview***
- *Spring activities*
- *Teaching*
- *Ph.D. courses*
- *Future work*

Overview – FRANC3D

Introduction

General procedure:



- *Agenda*
- *Project infos*
- *Overview*
- ***Spring activities***
- *Teaching*
- *Ph.D. courses*
- *Future work*

Spring activities – IN792

First part of project

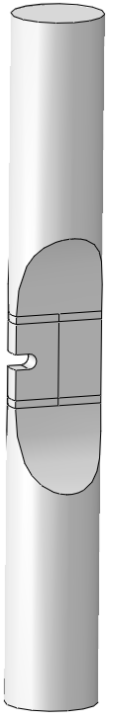
- Write paper about methodolgies of TMF crack propagtion simulations using FRANC3D

Content:

- Method using LE elements around crack tip
- ”Newman method”
- Comparison to lab tests

Difficulties:

- Current Lab tests are LCF-tests
- Waiting for TMF test results performed by SiT

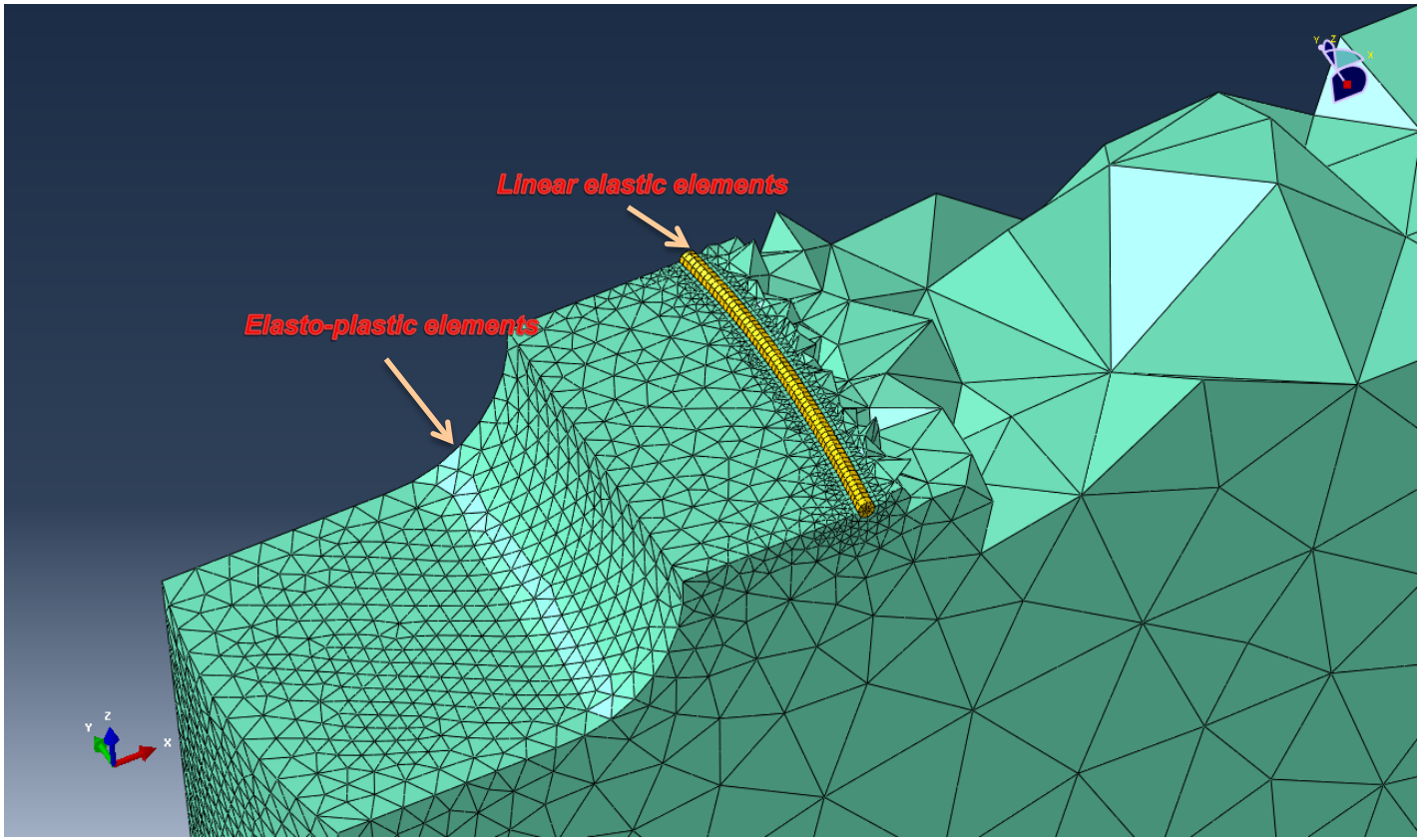


- *Agenda*
- *Project infos*
- *Overview*
- ***Spring activities***
- *Teaching*
- *Ph.D. courses*
- *Future work*

Spring activities – IN792

Methodology

- LE elements around crack tip

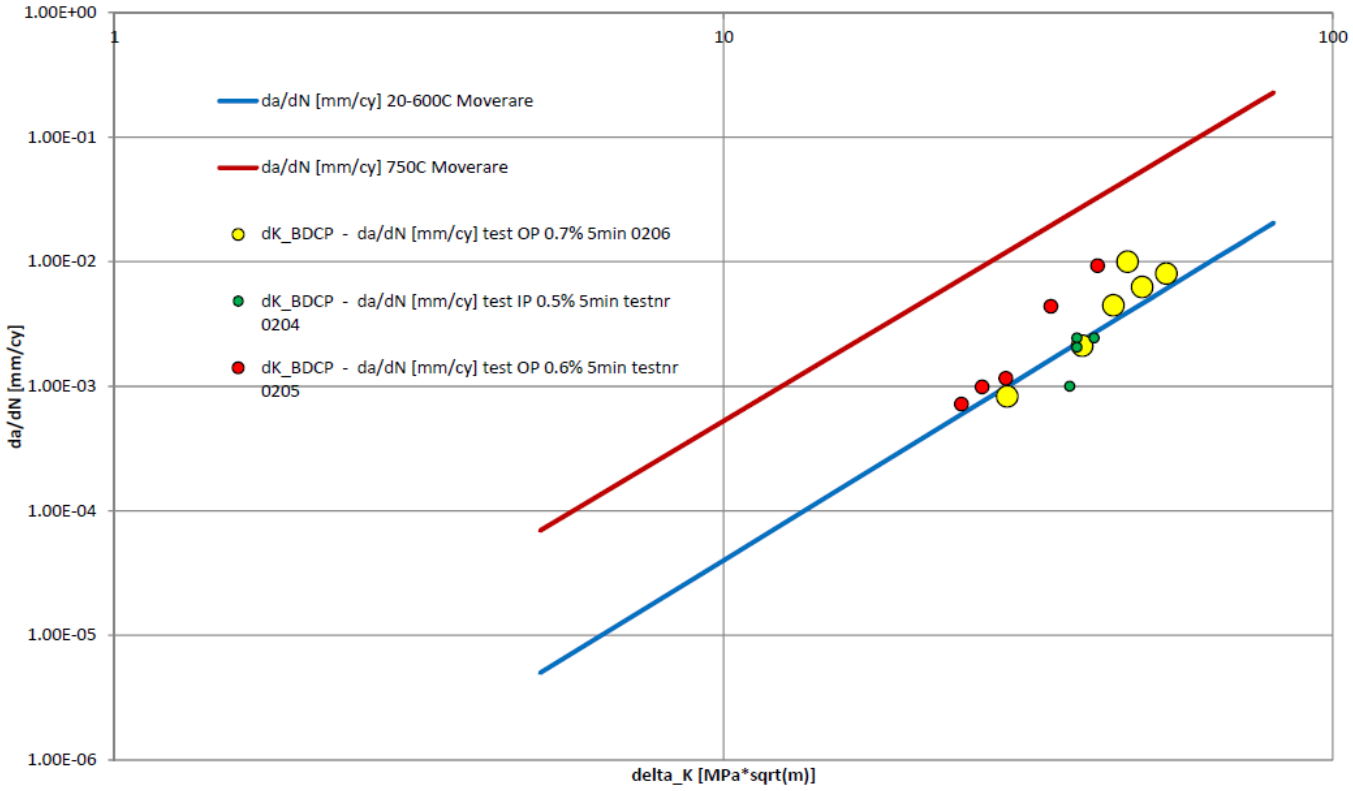


- *Agenda*
- *Project infos*
- *Overview*
- ***Spring activities***
- *Teaching*
- *Ph.D. courses*
- *Future work*

Spring activities – IN792

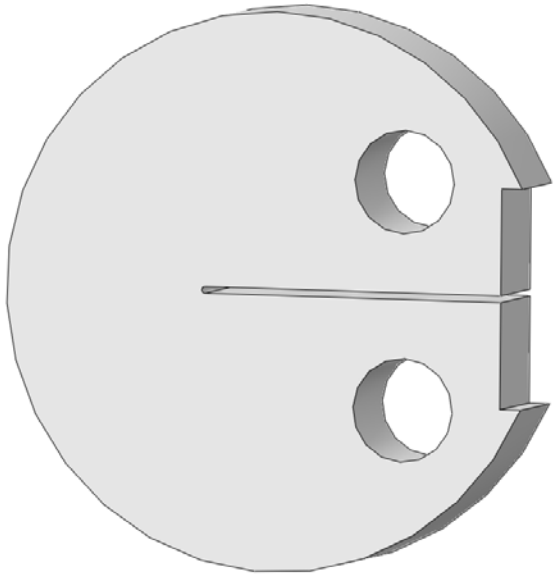
Preliminary results

- LE elements around crack tip



Spring activities – Pacman

- LCF crack propagation testing on the ”Pacman” DCT specimen made of STAL15
- Advantages with specimen geometry:
  - Easy manufacturing of different thicknesses
  - Easy manufacturing of different crystal orientations
  - Raw material already present from SiT

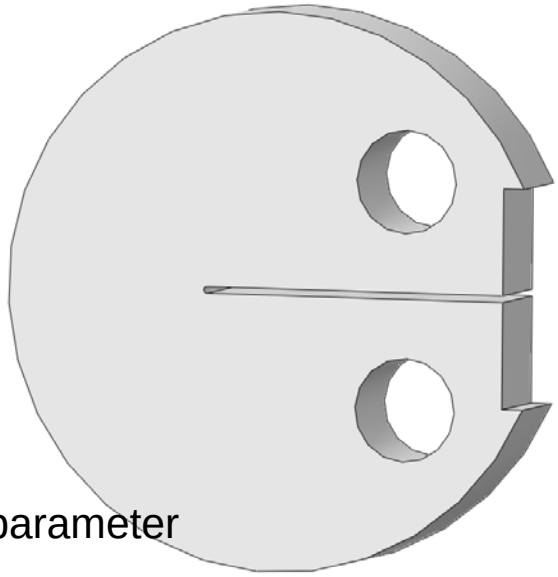


- *Agenda*
- *Project infos*
- *Overview*
- ***Spring activities***
- *Teaching*
- *Ph.D. courses*
- *Future work*

Spring activities – Pacman

To do:

- Find best boundary conditions for simulations
- Test model with BC's in FRANC3D and compare with handbook solutions
- Perform isothermal tension/compression testings at RT, 500C, 750C and in [001], [011] and [111]
- Get material model for single-crystals working in ABAQUS
- Calibrate model with material parameters
- Generate crack growth parameter



- *Agenda*
- *Project infos*
- *Overview*
- *Spring activities*
- ***Teaching***
- *Ph.D. courses*
- *Future work*

Teaching activities in 2015

- TMHL14 – DPU basic course for 1 class, VT1
- TMHL62 – Advanced FEM laborations, VT2
- TMHL22 – M basic course lessons for 2 classes, HT1
- TMHL19 – Advanced material and computational mechanics laborations, HT1

- *Agenda*
- *Project infos*
- *Overview*
- *Spring activities*
- *Teaching*
- ***Courses***
- *Future work*

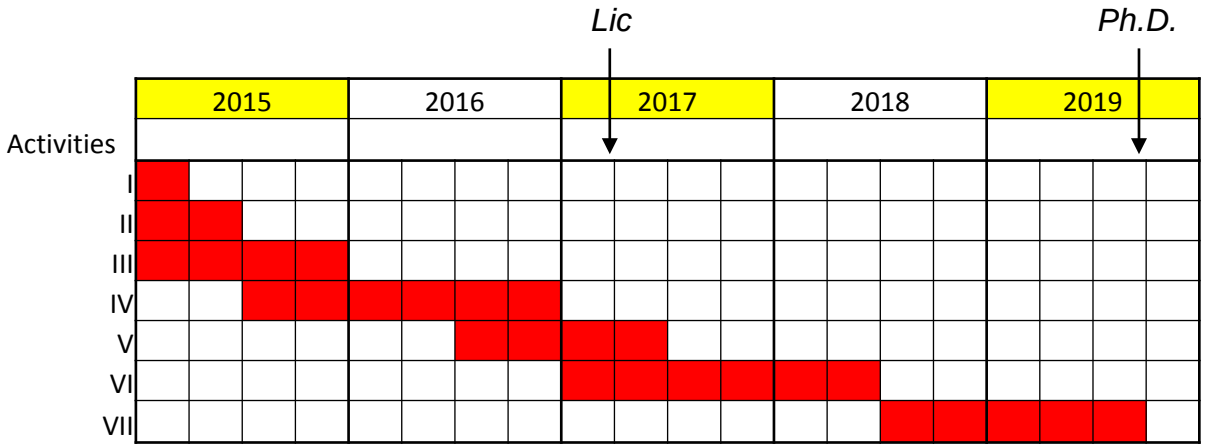
Ph.D. courses

- Advanced FEM, 10P
- Continuums mechanics, 10P
- Material models, 10P
- Superalloys, 8P
- Fatigue, 10P
- Methodology / Ethics, 6P
- Pedagogics I, 6P
- Total: 60P

- *Agenda*
- *Project infos*
- *Overview*
- *Spring activities*
- *Teaching*
- *Ph.D. courses*
- ***Future work***

Future Work

Project Plan



I : Finishing paper on IN718 LCF crack growth (master thesis)
II : Finishing TMF crack growth investigations on IN792 and write paper
III : Pacman simulations of LCF tests on STAL15 SX
IV : TMF crack propagation behaviour, Hold-time and creep influences
V : Same as IV but aging is considered
VI : More component like geometries are considered
VII: Open

Linköpings universitet

www.liu.se