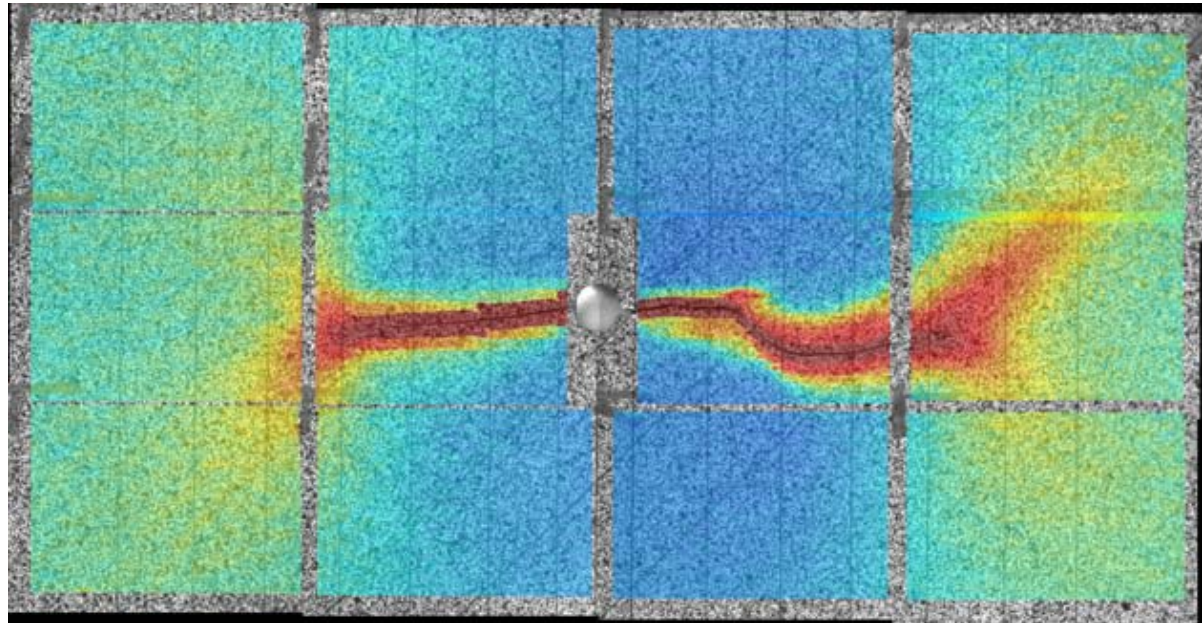


Detailed strain field analyses of fatigue cracks in friction stir welded joints

ICAF 2009, Rotterdam



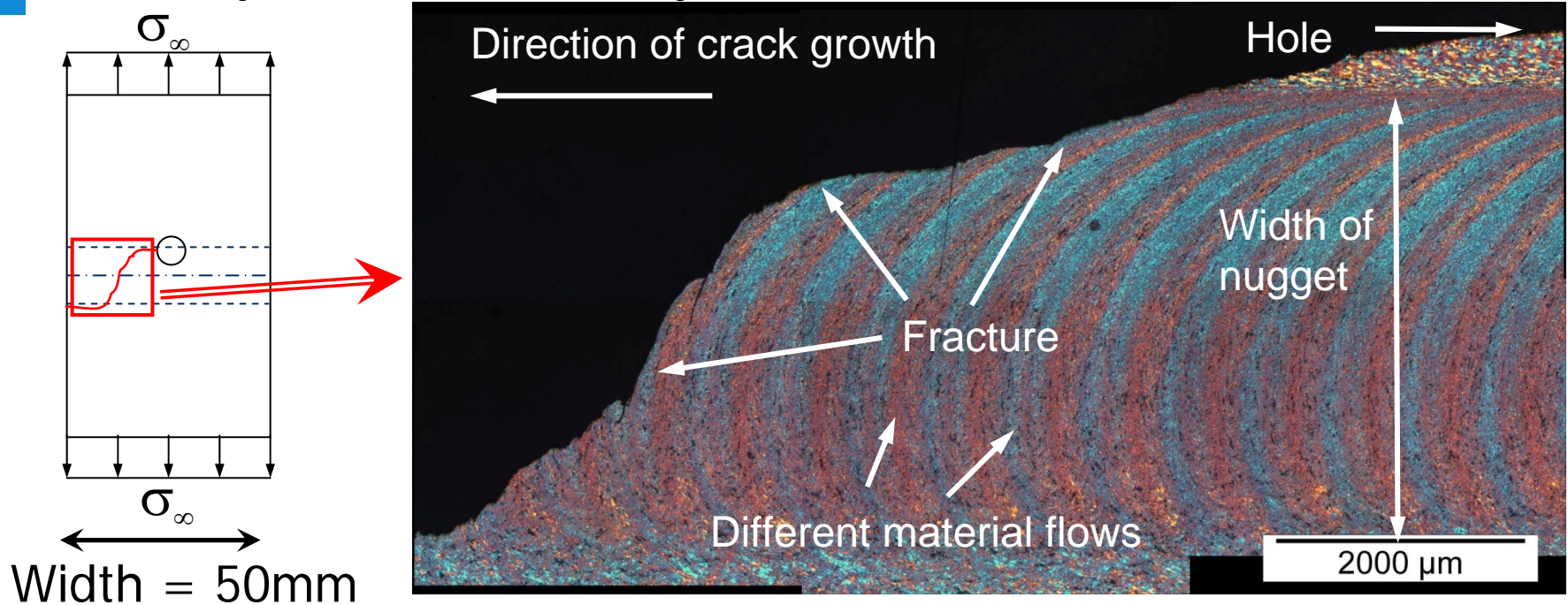
H.J.K. Lemmen,
R.C. Alderliesten,
R. Benedictus

Aerospace Structures and Materials, Faculty of Aerospace Engineering

6-7-2009

Introduction

ICAF 2007: Fatigue crack initiation behaviour of friction stir welded joints in aluminium alloy



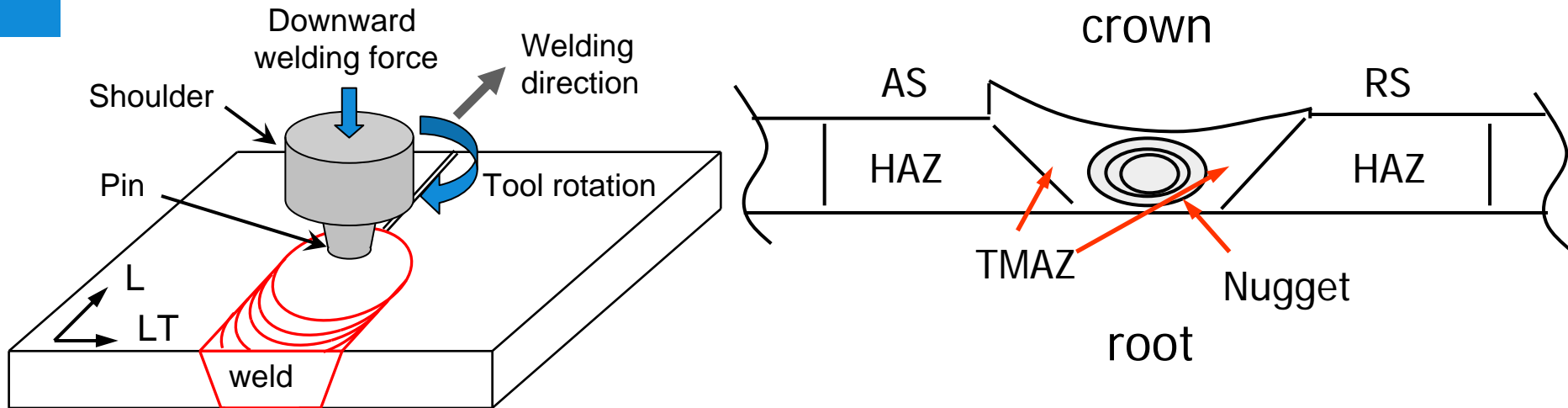
How affects an FS weld the fatigue crack growth behaviour?

Contents

- Introduction
- Friction Stir (FS) welding
 - Residual stress profiles
 - Yield strength profiles
- Fatigue Crack Growth (FCG) test
 - Loads & specimen configuration
 - Digital Image Correlation (DIC)
- FCG test results
 - FCG curves
 - Results from DIC
- Conclusions
- Questions

Friction Stir Welding

FS welding performed by EADS in Munich

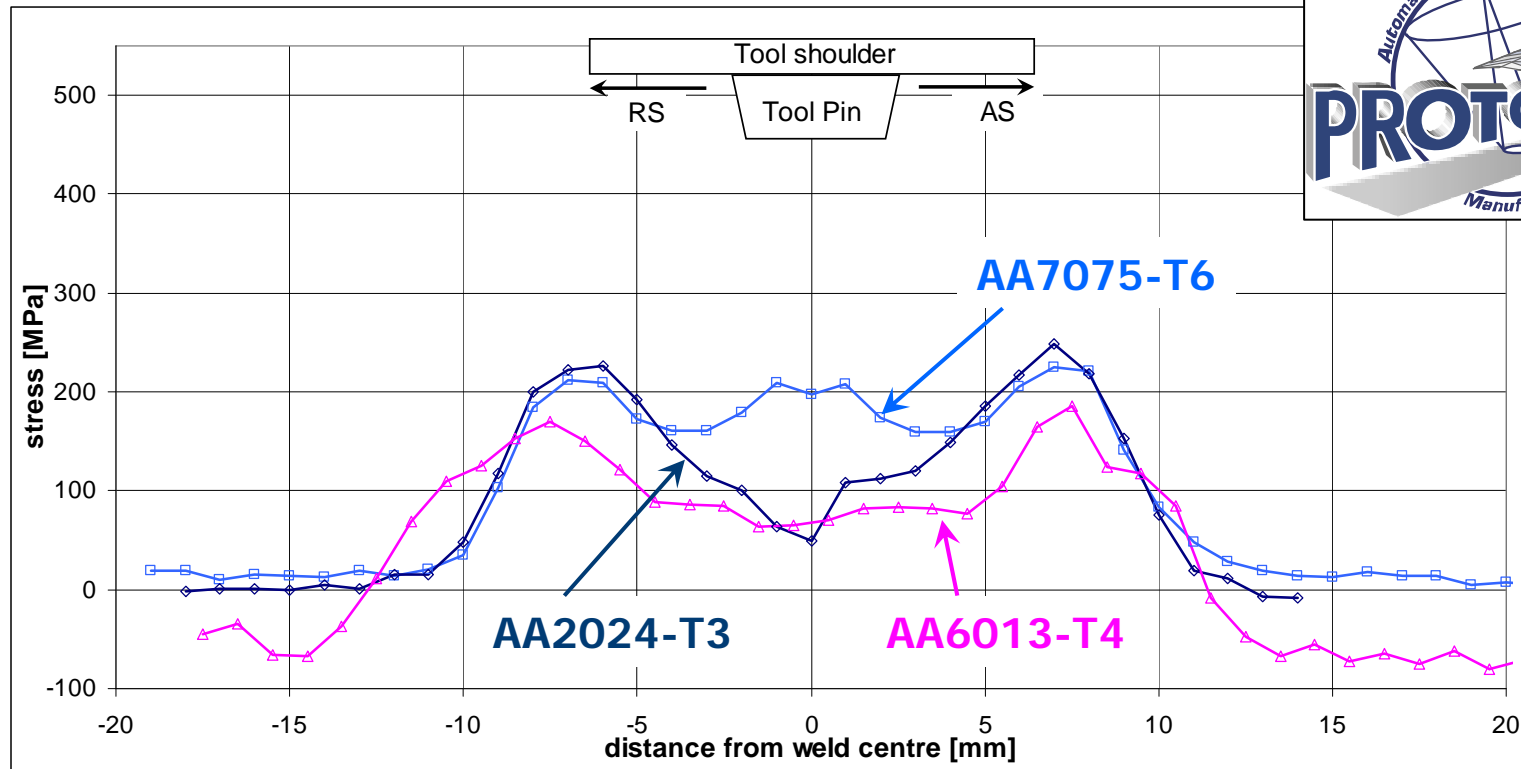
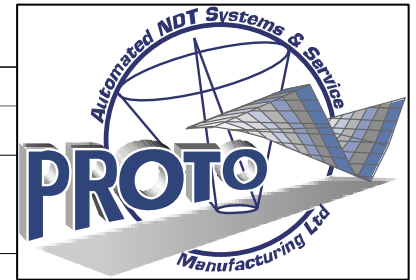


Advancing Side (AS)

 Retreating Side (RS)

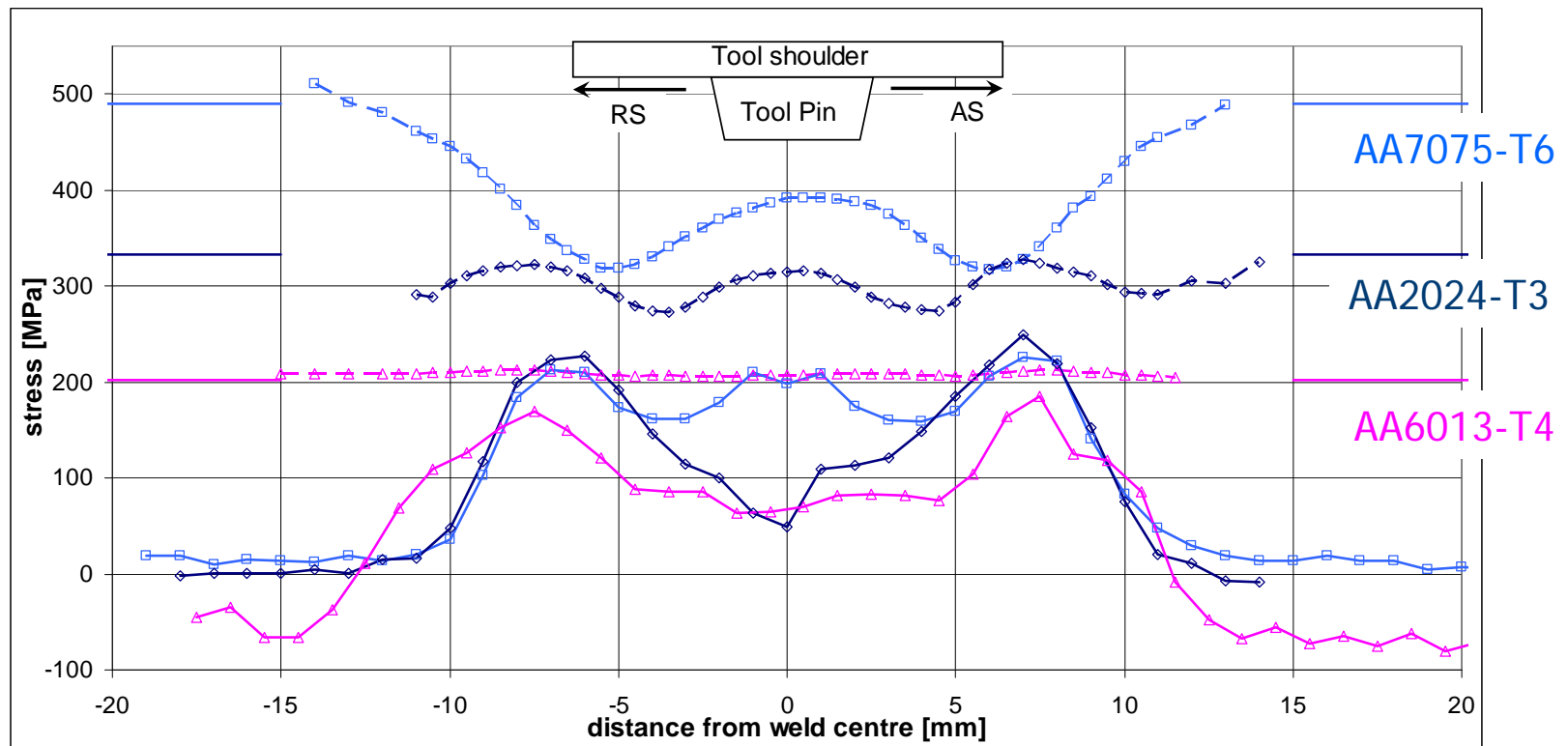
Process parameters:	Alloys:		
	AA2024-T3	AA7075-T6	AA6013-T4
Thickness:	2.5 mm	2.0 mm	1.8 mm
Welding speed:	350 mm/min	300 mm/min	1000 mm/min
Rotational speed:	550 rpm	280 rpm	1500 rpm
Downward force:	19 kN	18 kN	14 kN

Residual stress profiles in FS welds



Residual stresses measured by X-ray diffraction

Yield strength profiles of FS welds

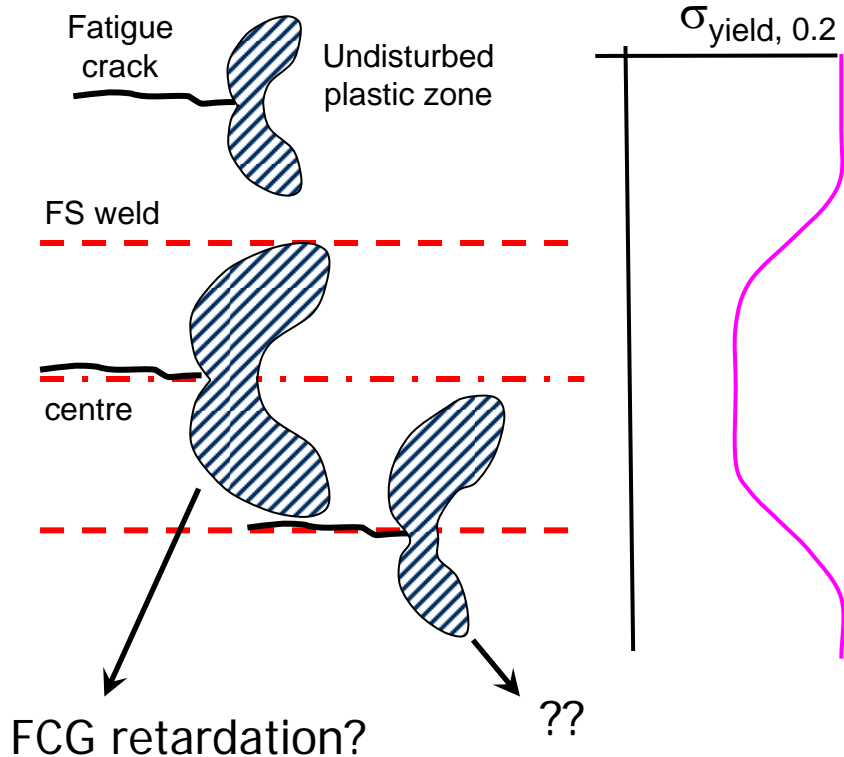


results presented at AIAA/SDM conference 2008

FS weld properties & FCG behaviour

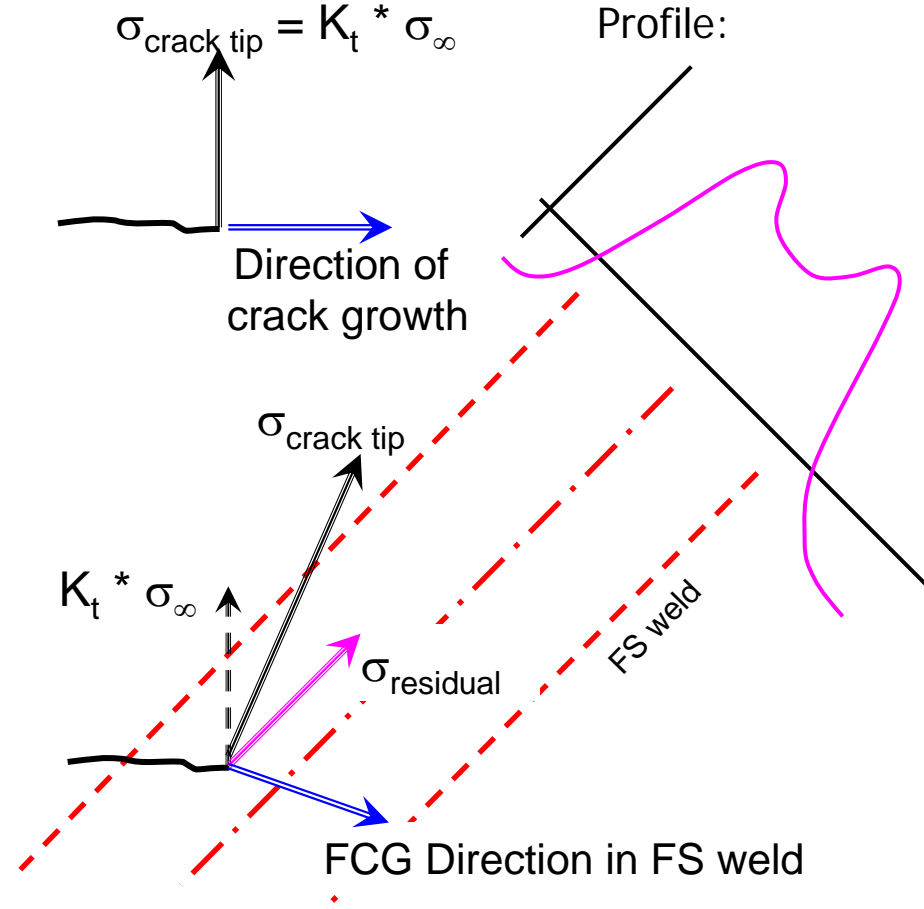
yield strength:

Yield strength profile:



residual stress:

Residual stress Profile:

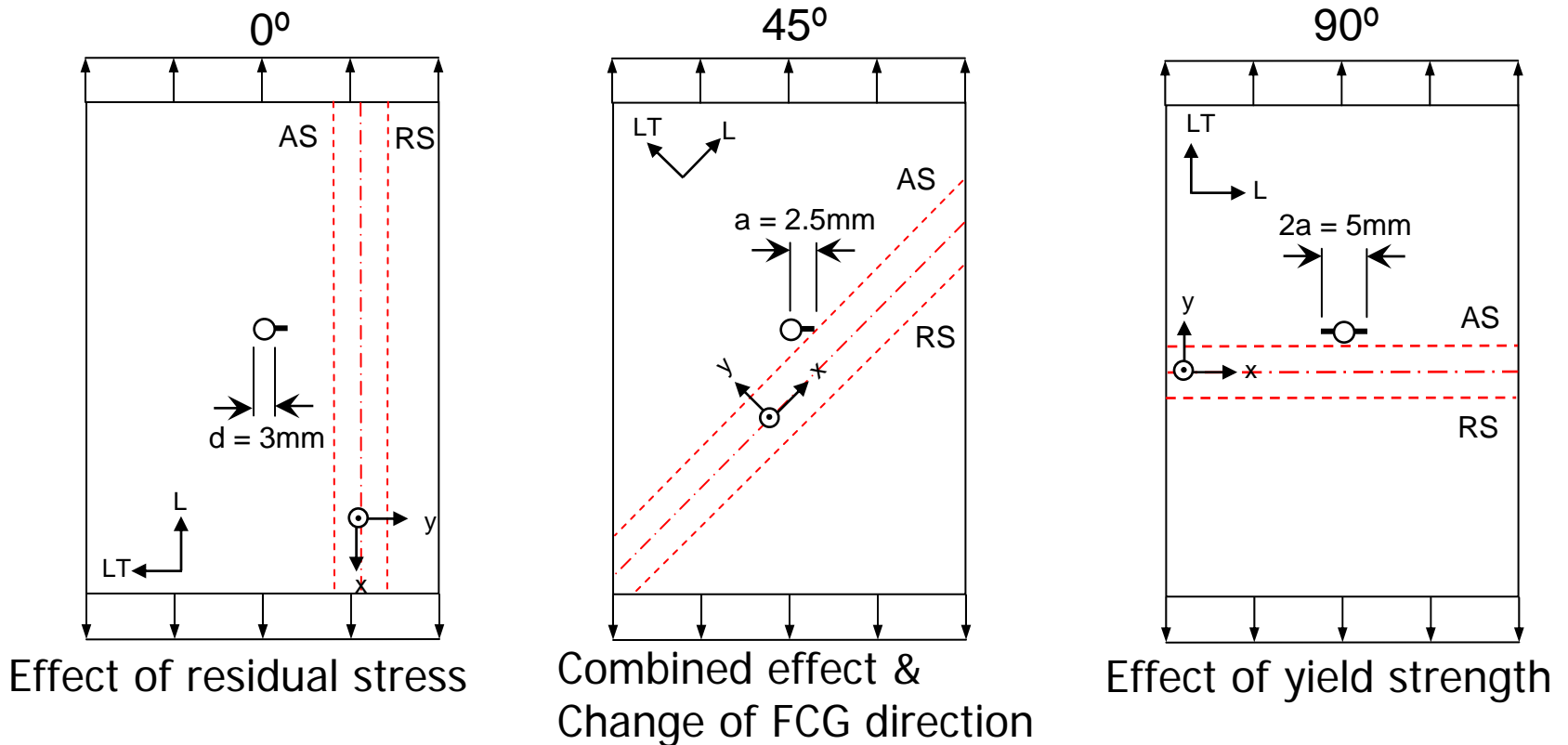


Fatigue crack growth test

Goal: to repeat and measure the behaviour observed in the FI specimen

Constant amplitude loading; $R = 0.1$; $\sigma_a = 60\text{MPa}$

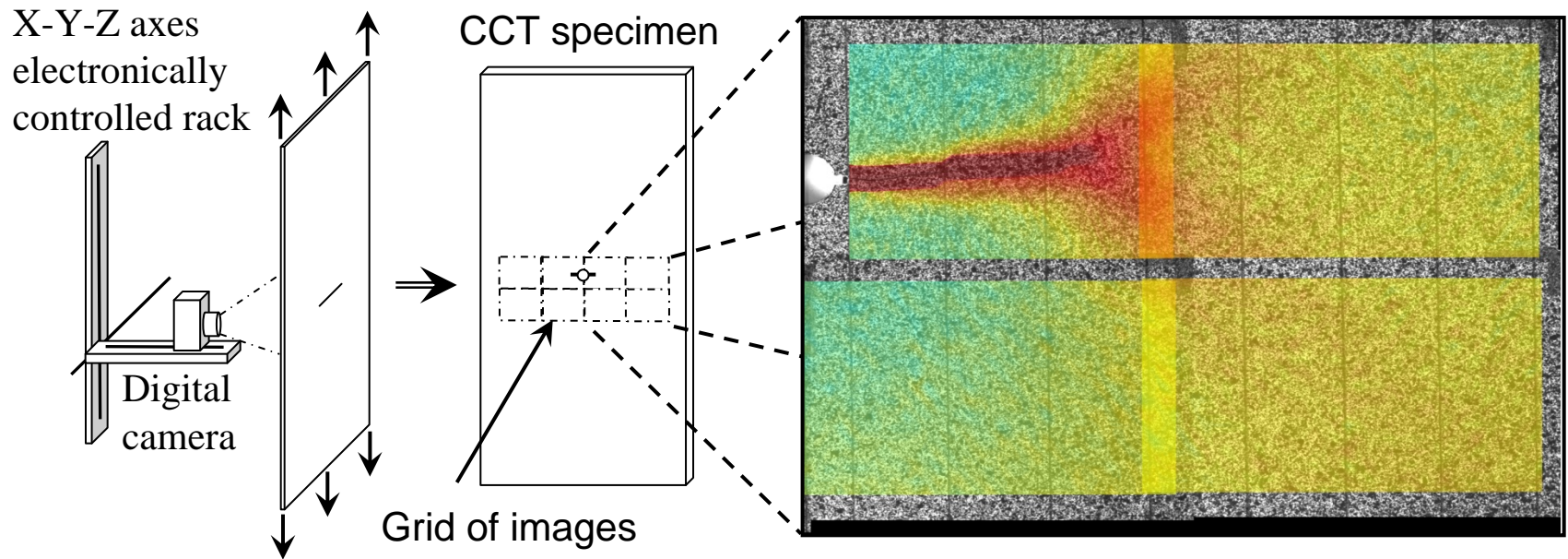
Three configurations of centre crack FCG test specimen:



Digital image correlation

Strains are determined by analysing the images of a test
DIC software has been developed by the author

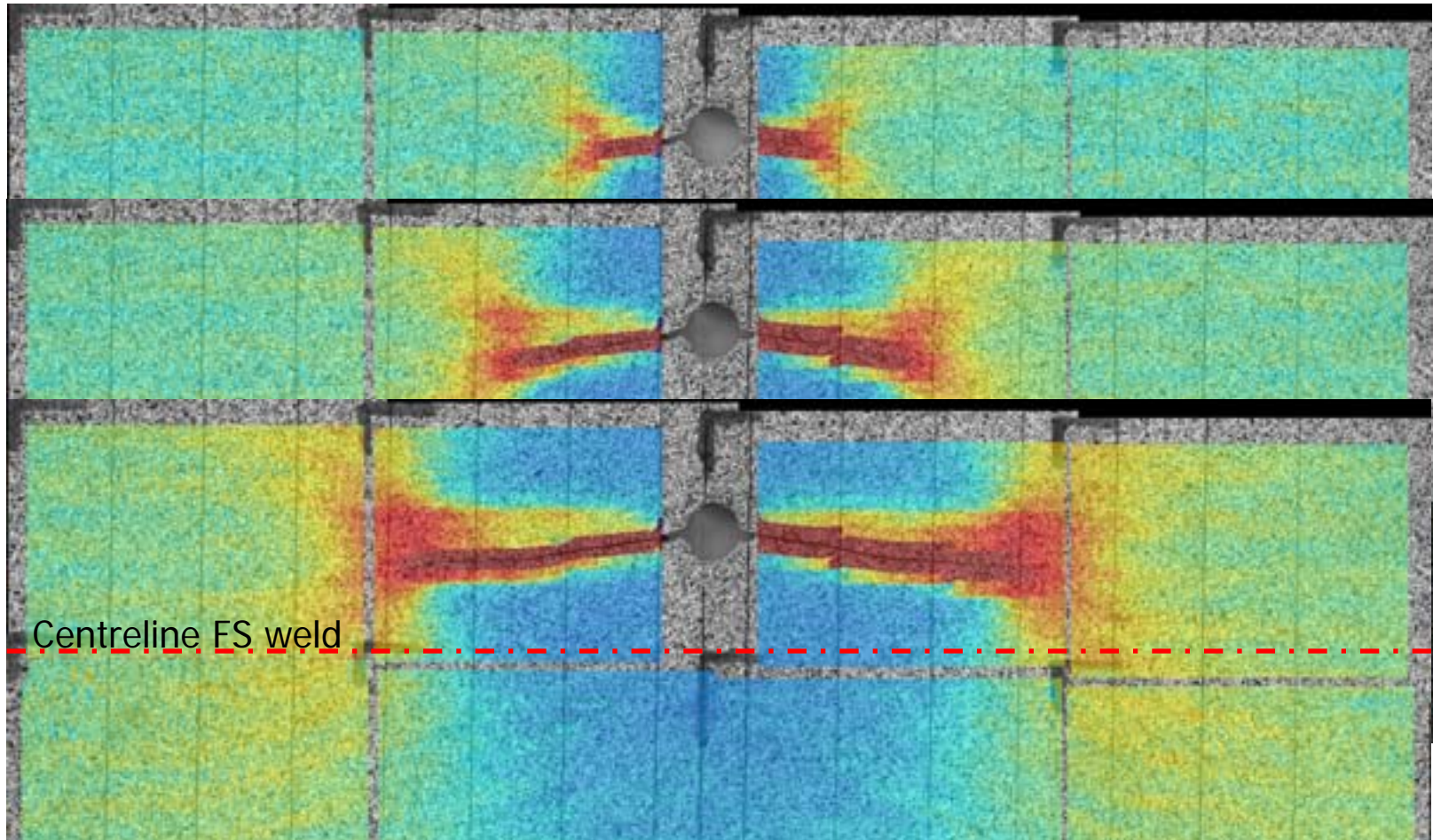
Images after DIC analyses,
with overlay of strain field



For examples of applications for this DIC tool have a look at the poster presentations of Mr. Wilson, Mr. Rodi, Mr. Khan, and Mr. Delgrange.

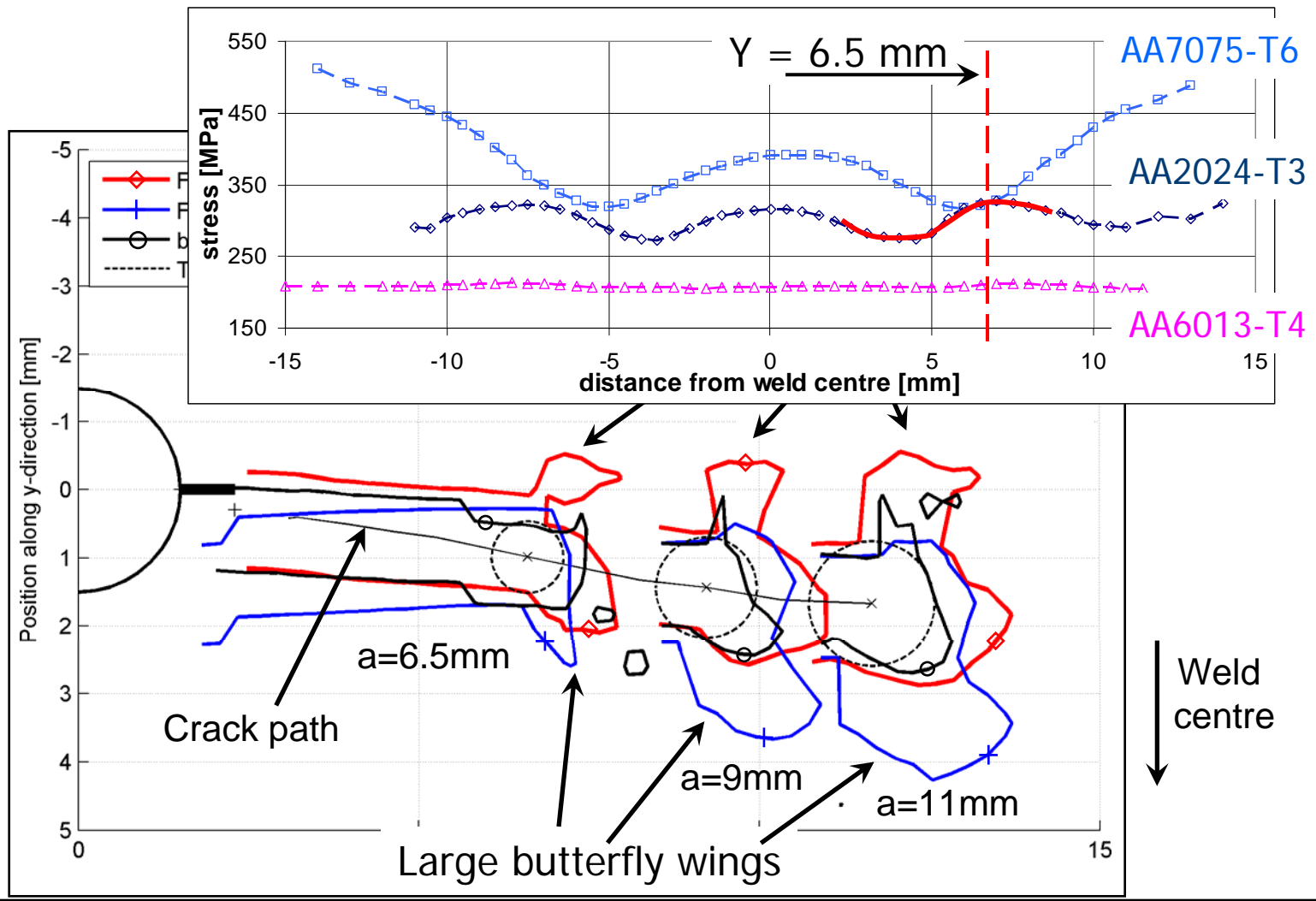
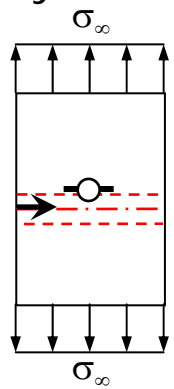
Results DIC

Details: alloy = AA2024-T3; 90° configuration; $y = 6.5\text{mm}$;



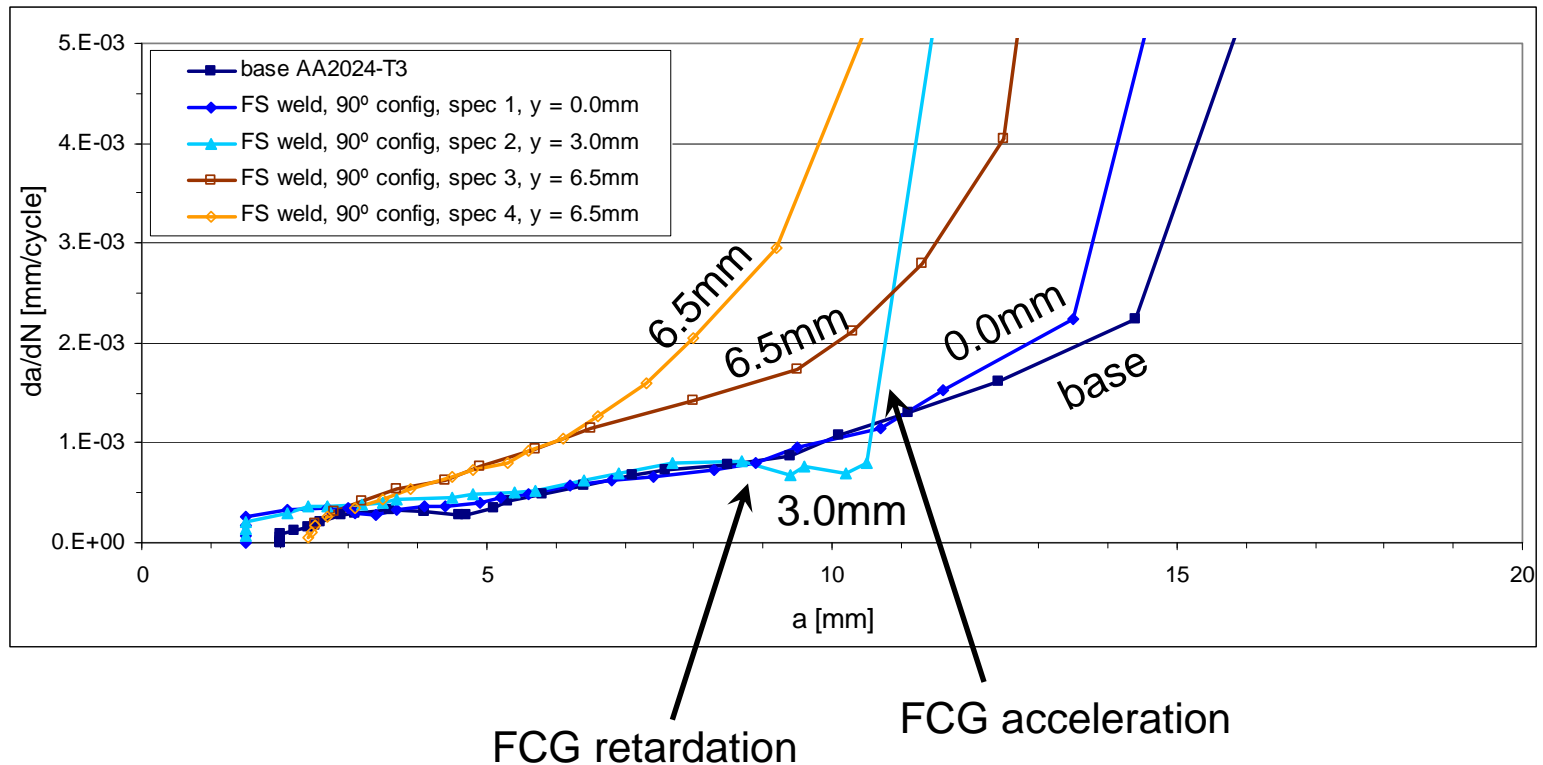
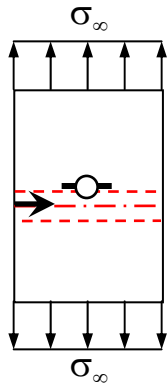
Plastic zone behaviour

- Details:
- > AA2024-T3;
 - > 90° conf.;
 - > $y = 6.5\text{mm}$;



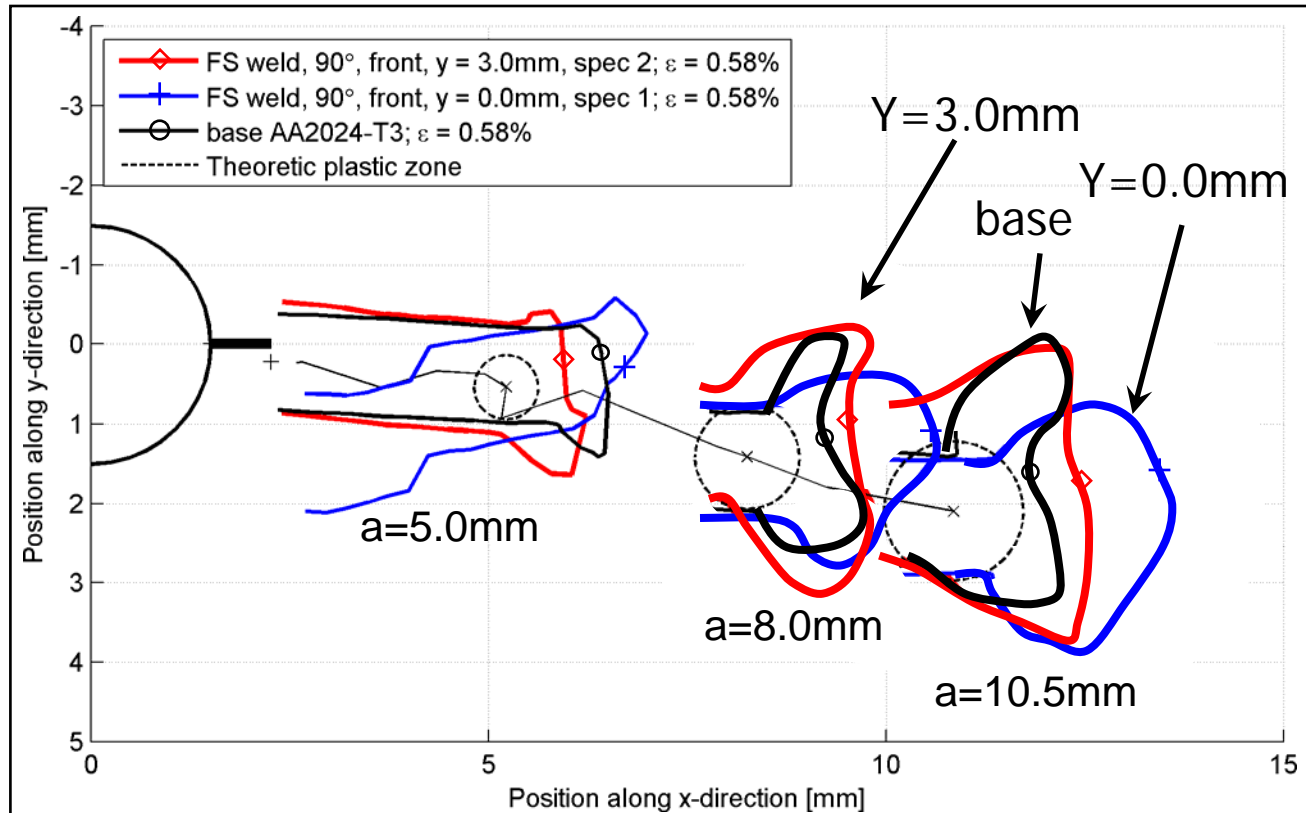
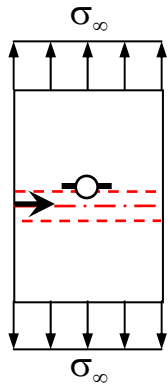
FCG behaviour 90° conf.

Details:
 > AA2024-T3;
 > 90° conf.;



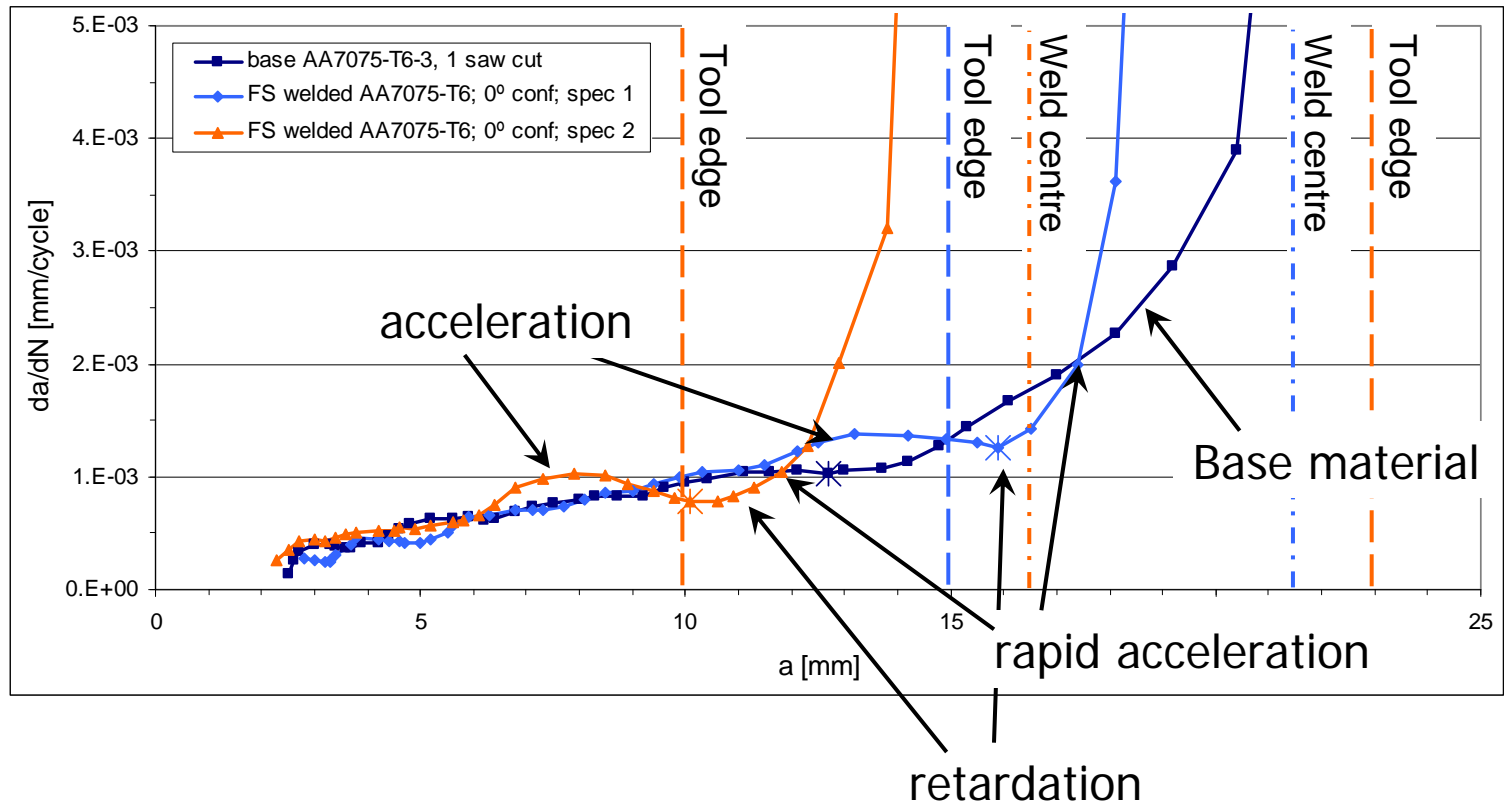
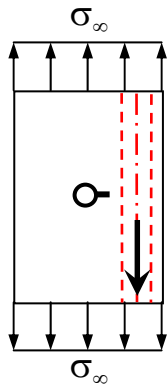
Plastic zone behaviour

Details:
> AA2024-T3;
> 90° conf.;

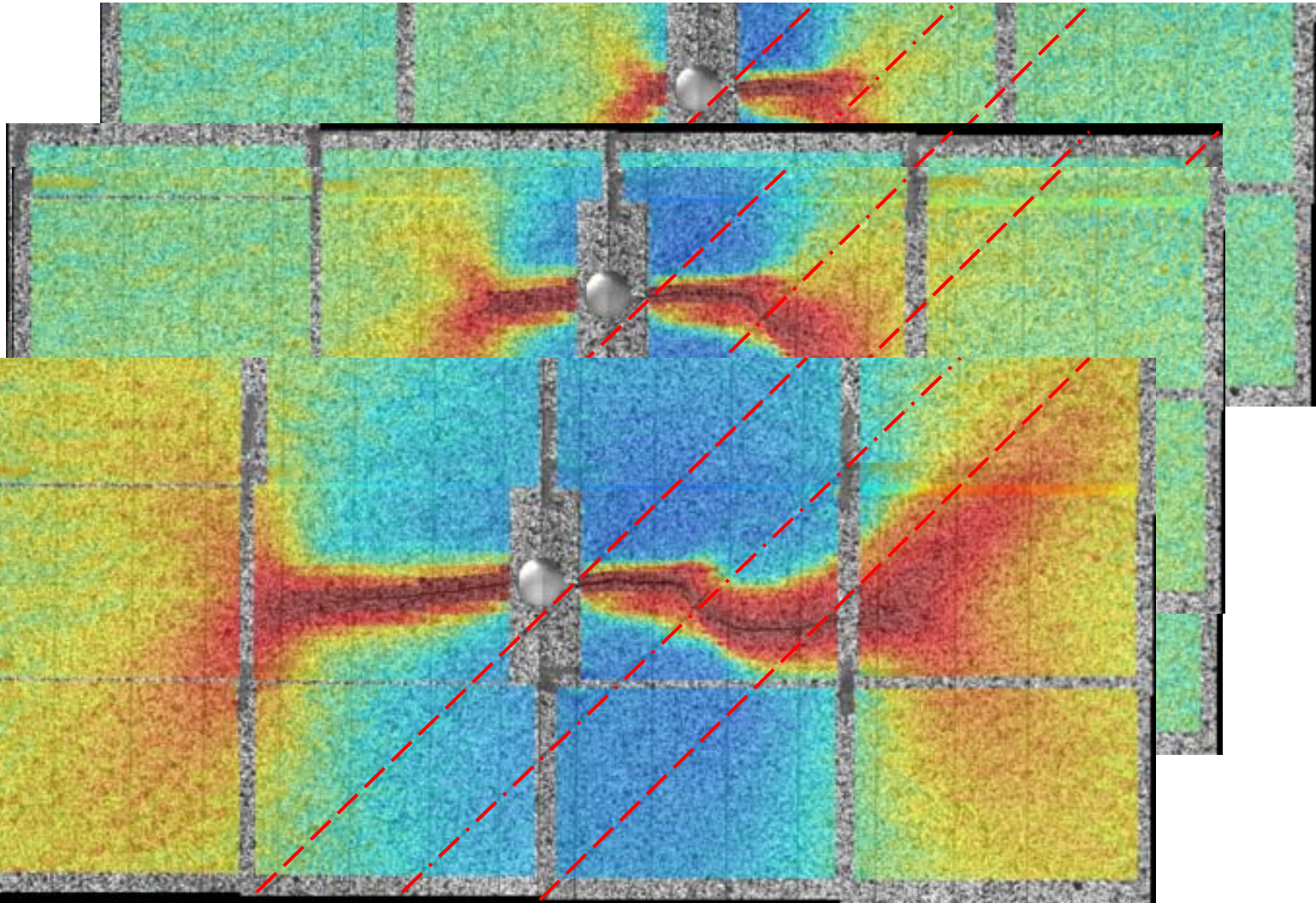


FCG behaviour 0° configuration

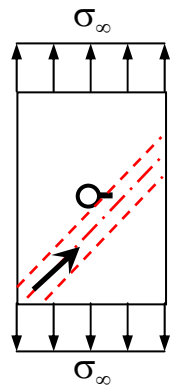
Details:
 > AA7075-T6;
 > 0° conf.;



FCG behaviour 45° behaviour

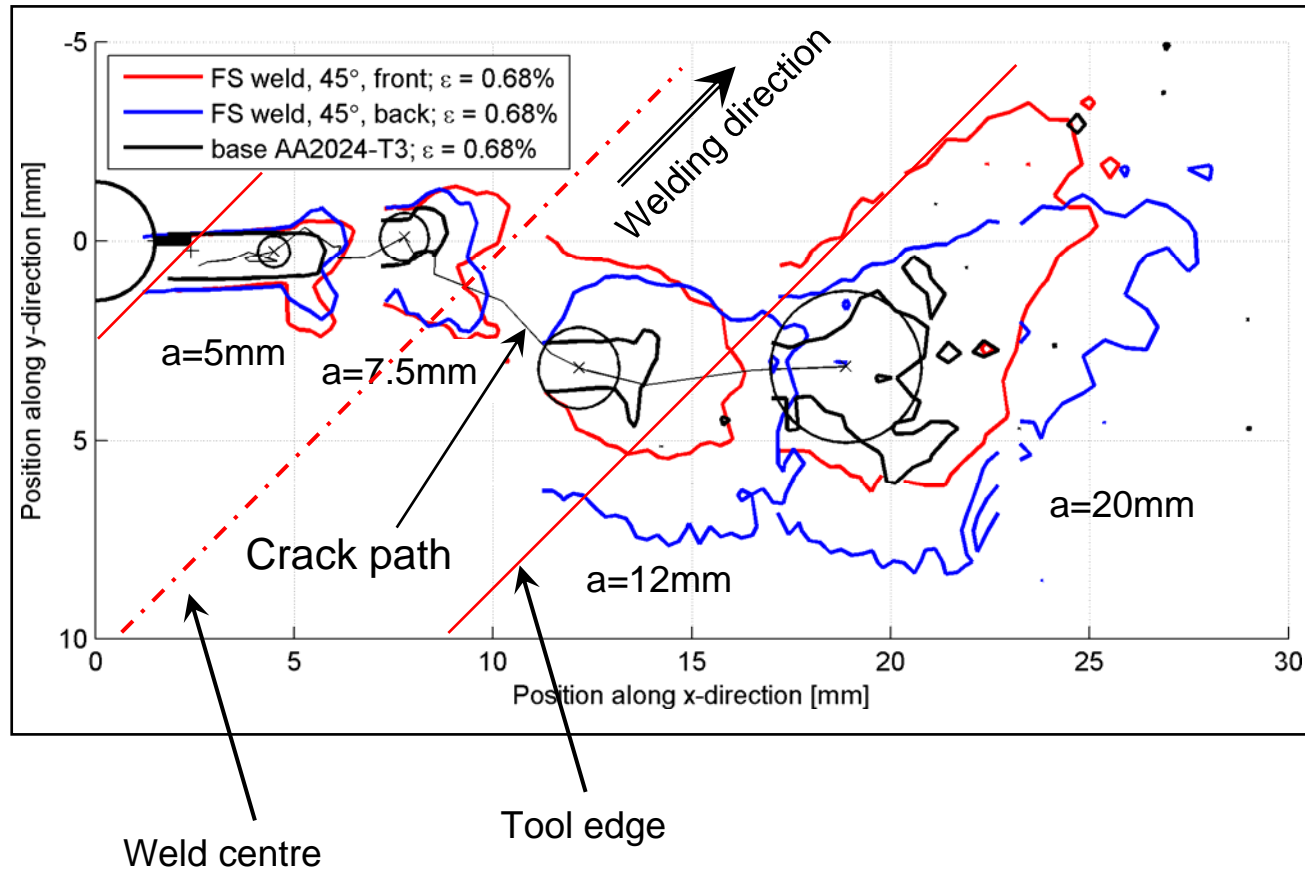
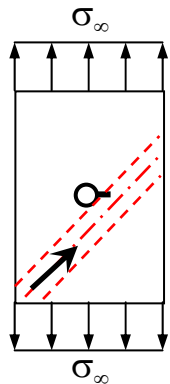


Details:
> AA2024-T3;
> 45° conf.;



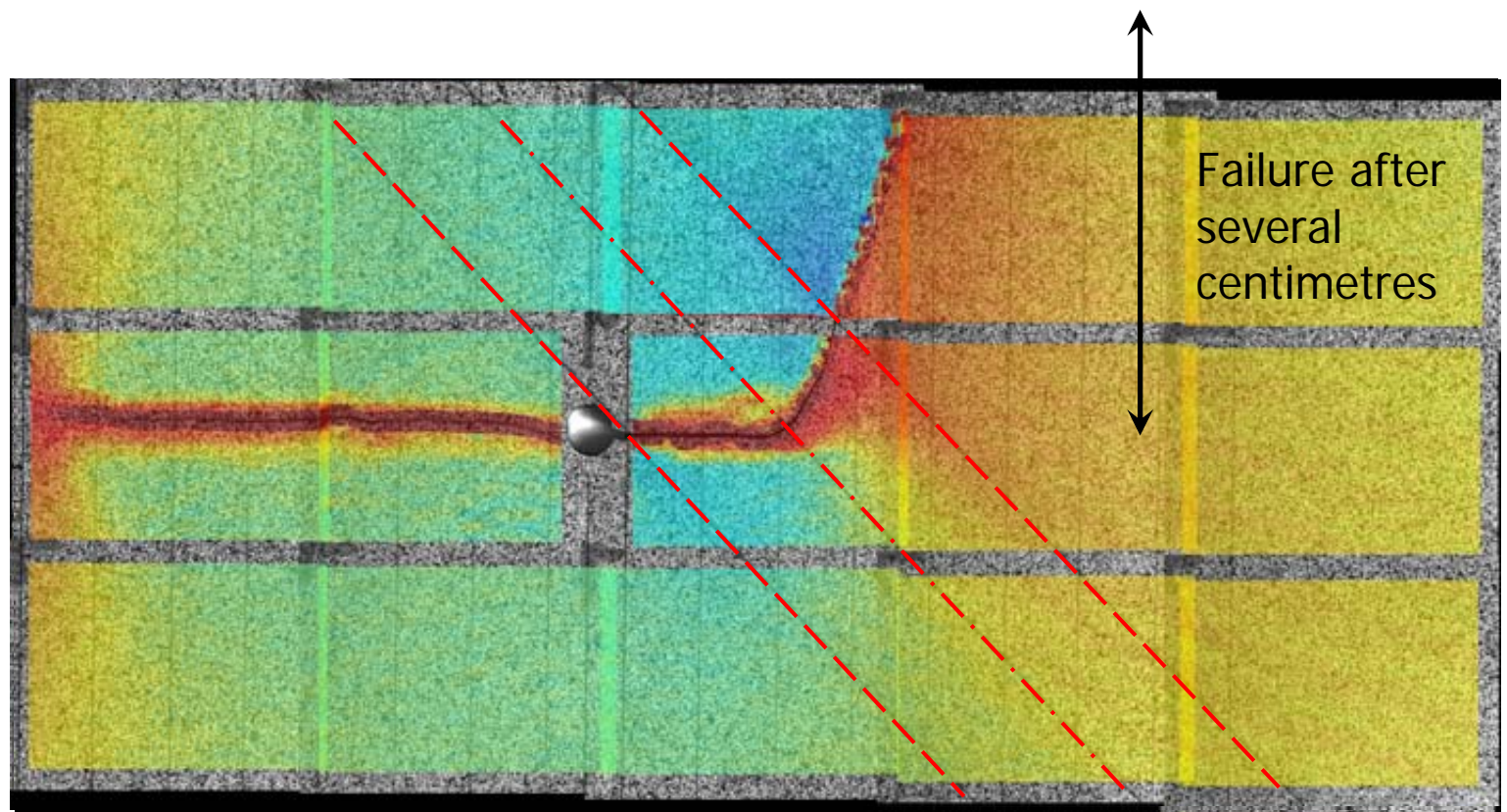
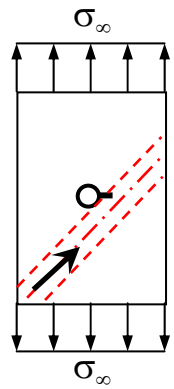
FCG behaviour 45° behaviour

Details:
> AA2024-T3;
> 45° conf.;



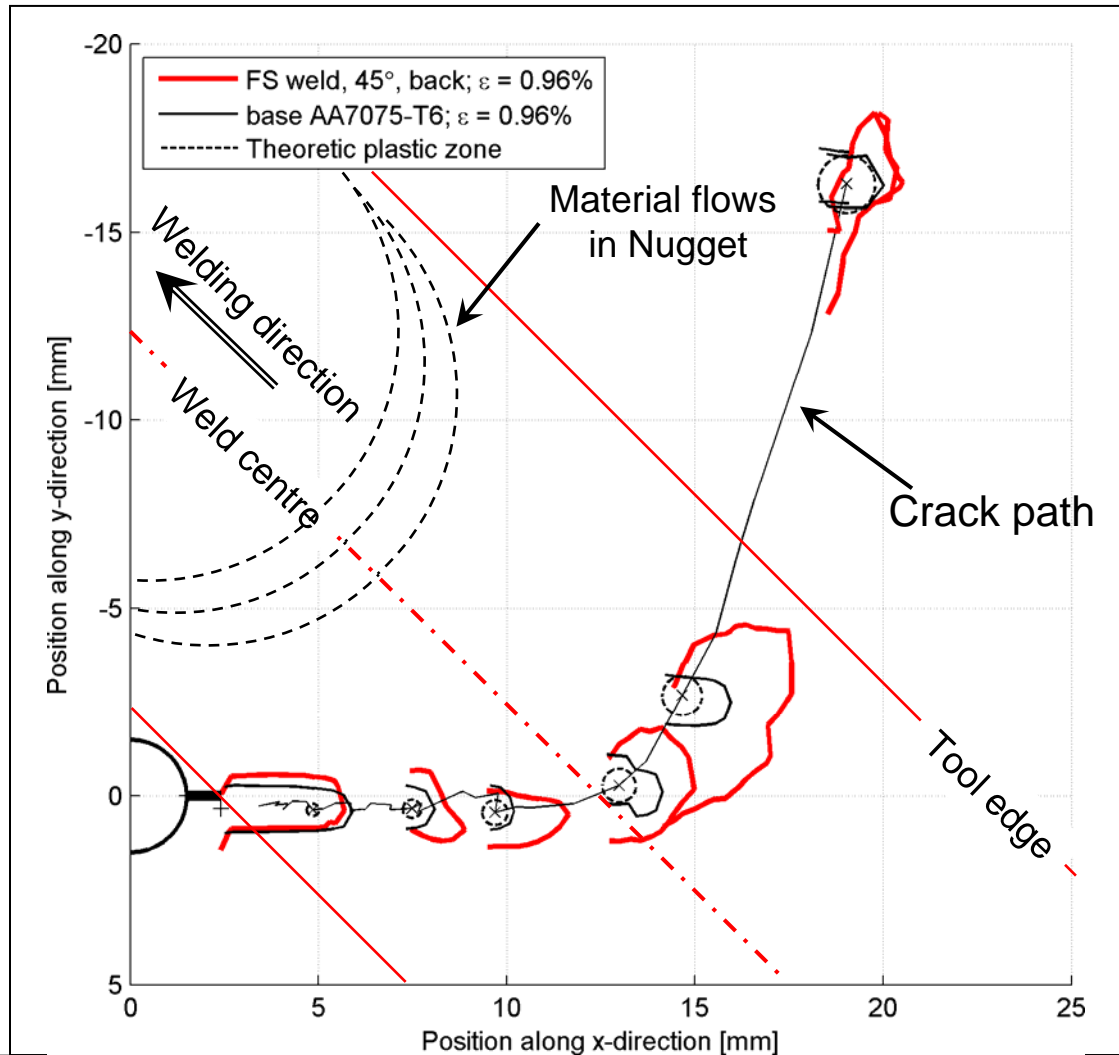
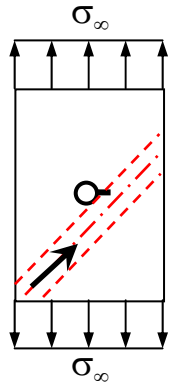
FCG behaviour 45° behaviour

Details:
> AA7075-T6;
> 45° conf.;



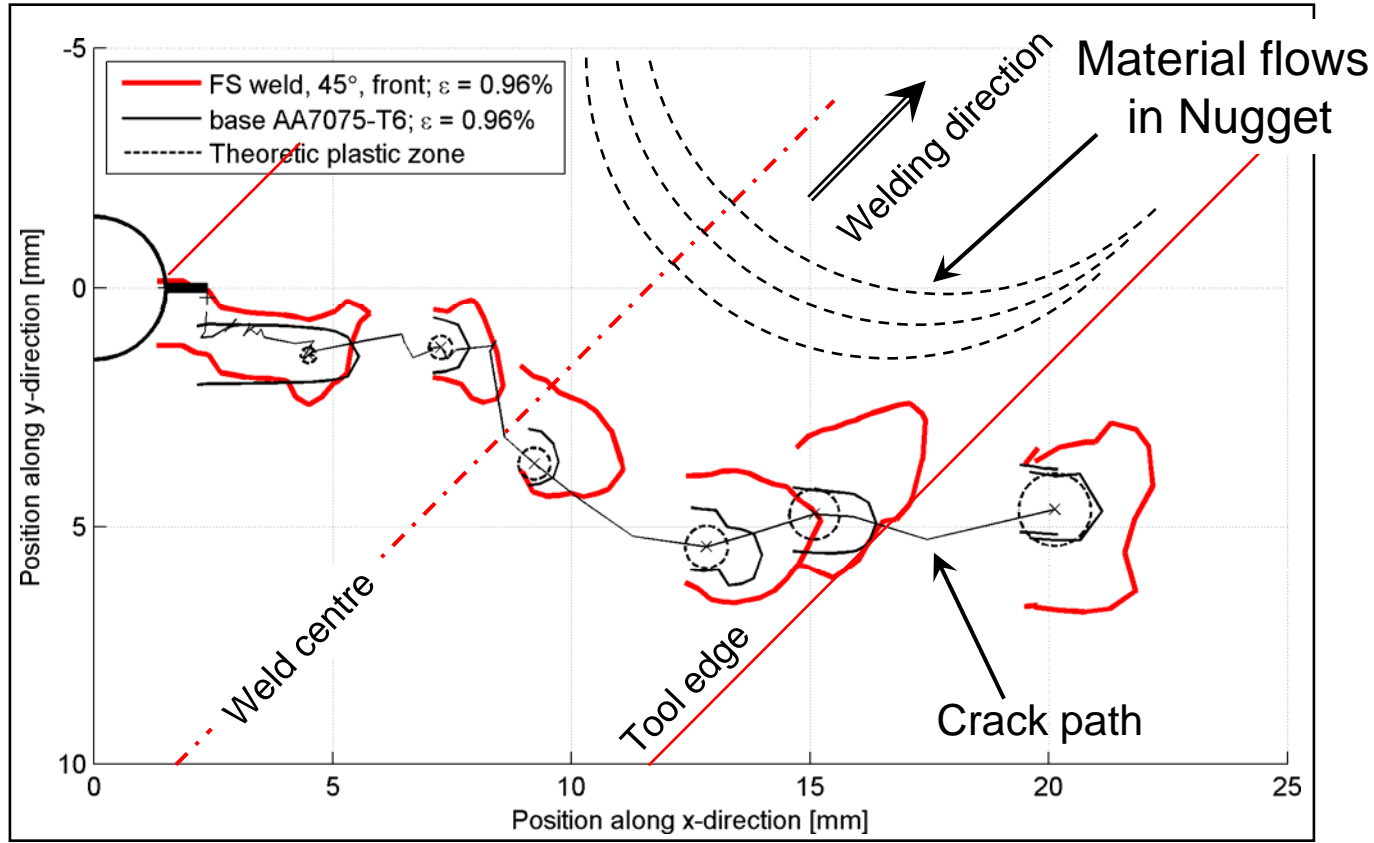
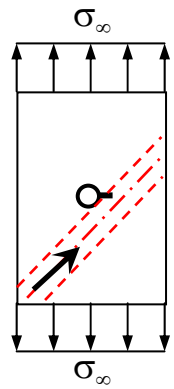
FCG behaviour 45° behaviour

Details:
> AA7075-T6;
> 45° conf.;



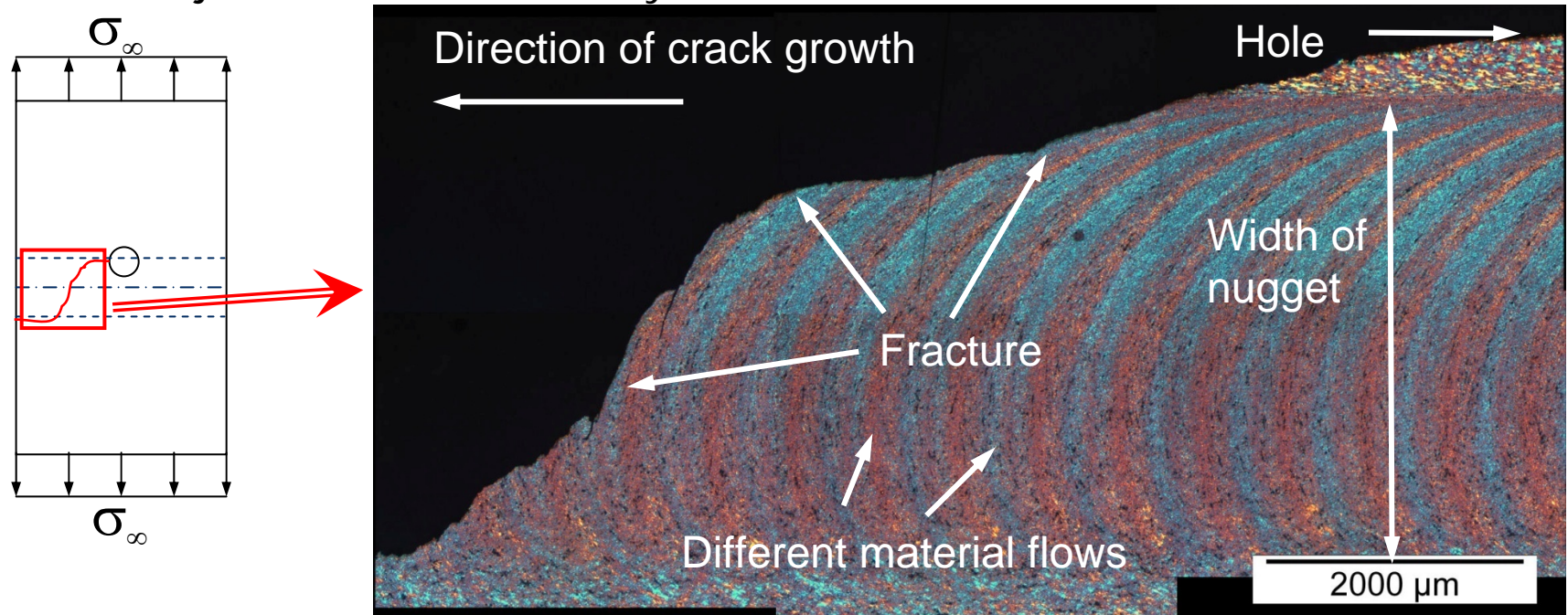
FCG behaviour 45° behaviour

Details:
 > AA7075-T6;
 > 45° conf.;



Introduction

ICAF 2007: Fatigue crack initiation behaviour of friction stir welded joints in aluminium alloy

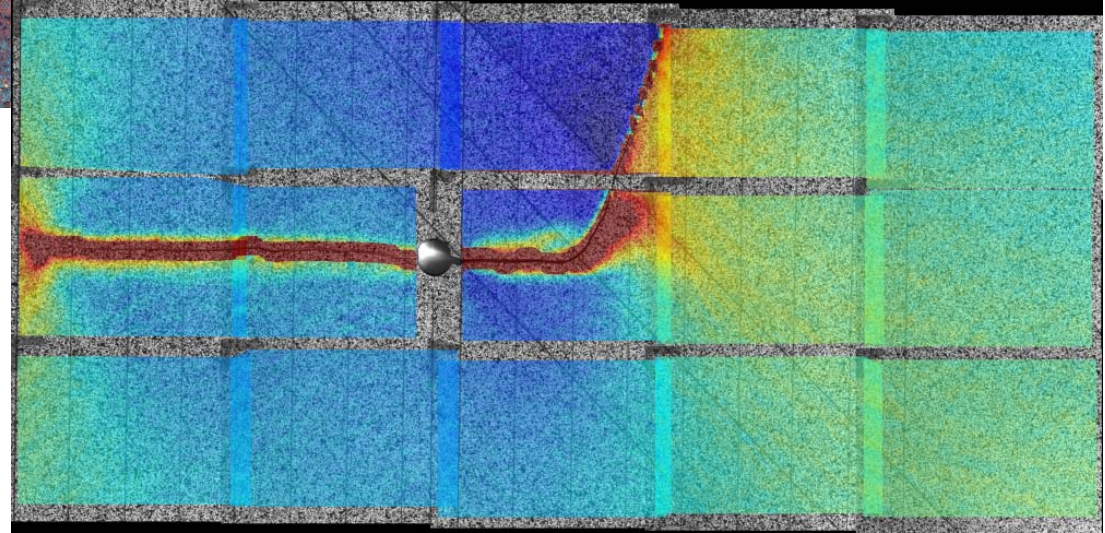
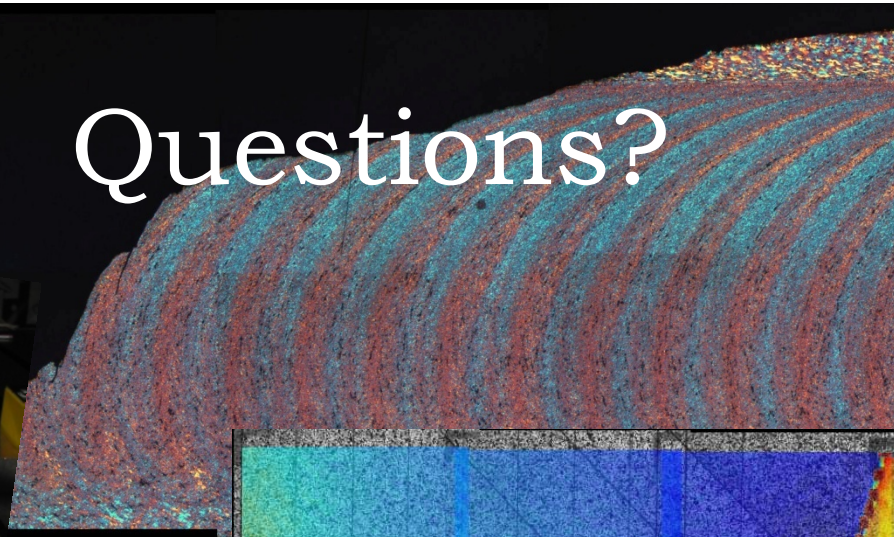


How affects an FS weld the fatigue crack growth behaviour?

Conclusions

- The yield strength affects the FCG rate, depending on the orientation of the FS weld.
- The residual stresses affect the FCG rate, with the largest effect found for the 90° configuration
- The micro structure in the nugget of the FS weld provides a path with low fatigue resistance
- Digital image correlation has a large potential in future research in fatigue.

Questions?



FCG behaviour 0° configuration

Details:
 > AA2024-T3;
 > 0° conf.;

