VALID

Verified Approaches to Life Management & Improved Design of High Temperature Steels for Advanced Steam Plants

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Technology Engineering

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Objective

To enhance the operation of high-efficiency power plants,

through improved lifetime performance of advanced CSEF materials and components,

by development and application of advanced innovative fabrication and repair processes.

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Why?

- Improving thermal efficiency of power plants
- Creep strength enhanced ferritic (CSEF) steels, typically used for boiler and steam piping components in power plants, capable of operating at temperatures above 550°C
- Welded joints in these materials perform poorly and suffer from the phenomenon of Type IV cracking, leading to problematic premature failures in industry.
- There is a need to better understand type IV cracking and improve the performance of weldments in long-term service to maximise the potential of these materials in new-build, and, to produce non-estructive in-service repair technologies to extend the life of the components already in operation.

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Example header assembly

Fabrication Process

Forming

- Press forming of headers and piping
- Bending of tubing
- Swaging of tube ends

Machining

- Weld grooves for header and pipe longitudinal and circumferential seams
- Socket weld grooves for tube-to-header joints
- Weld grooves for tube circumferential seams

Welding

- Submerged arc welding (SAW) for header and pipe longitudinal and circumferential seam
- Gas tungsten arc welding (GTAW) for tube-to-tube joints
- Shielded metal arc (SMAW) and gas tungsten arc welding (GTAW) for tube-to-header socket joints
- Dissimilar welds

Courtesy of Alstom

Viswanathan, 2007

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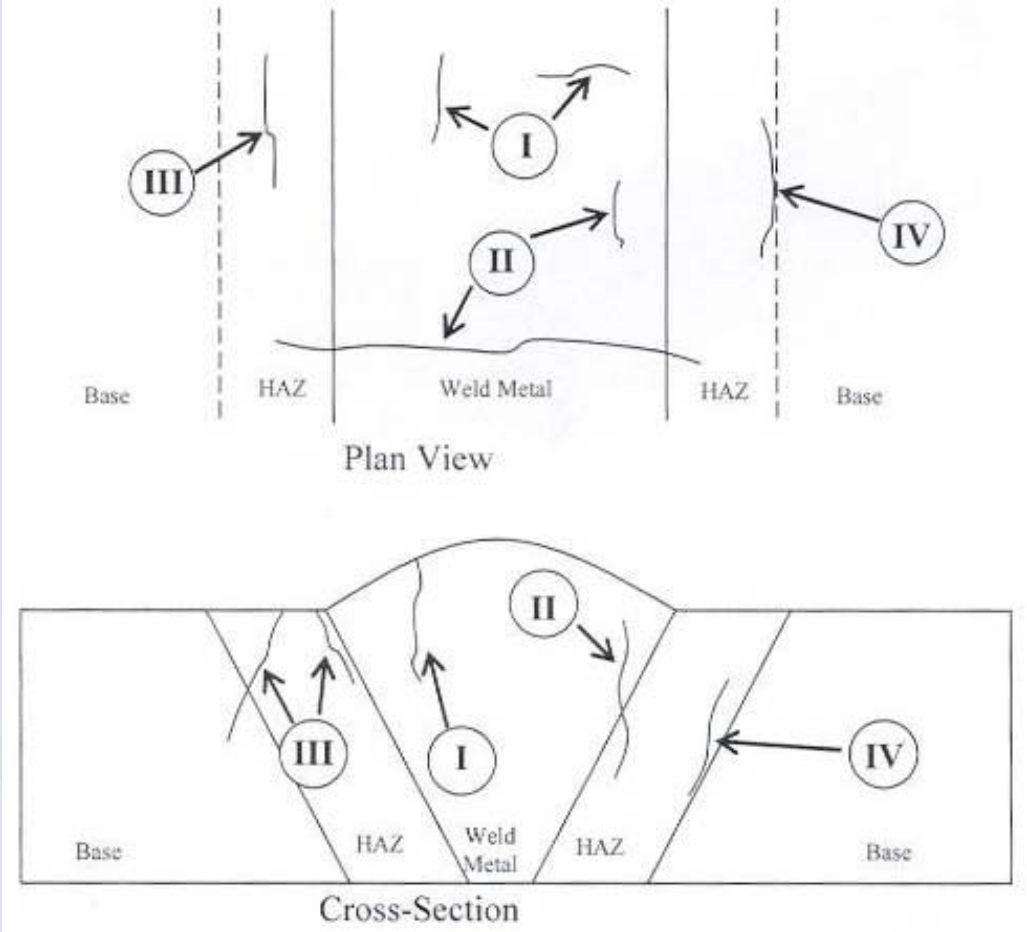
Type IV cracking

- Caused by the high-temperature service conditions
- Occurs in the intercritical or fine grain region of the HAZ via a creep mechanism, and results in fractures with relatively little total strain across the weld.



Brear and Fleming, 2004, according to Schüller et al., 1974

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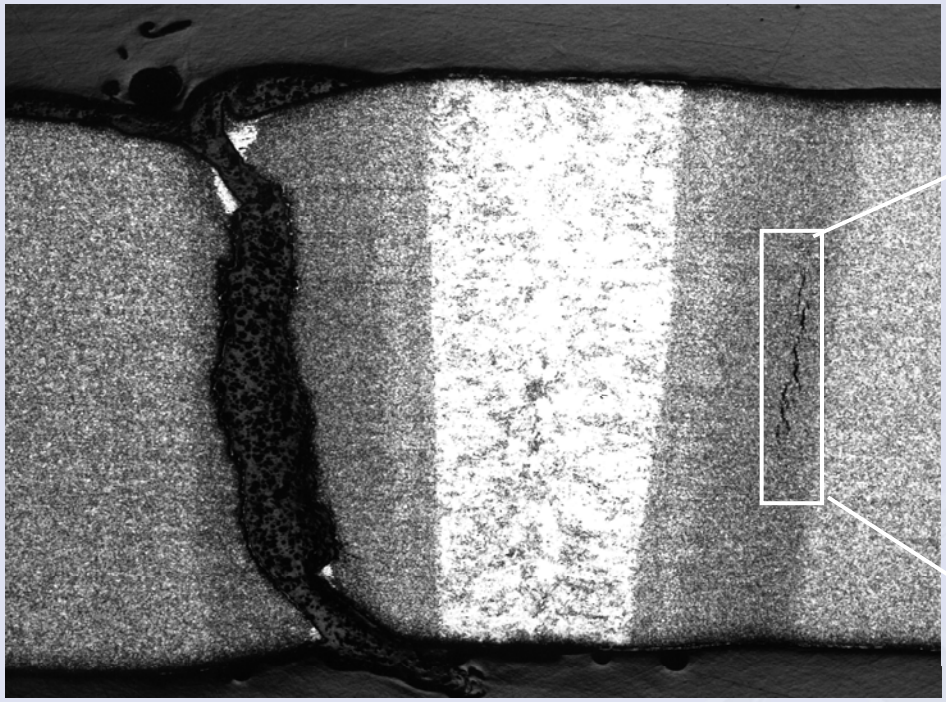
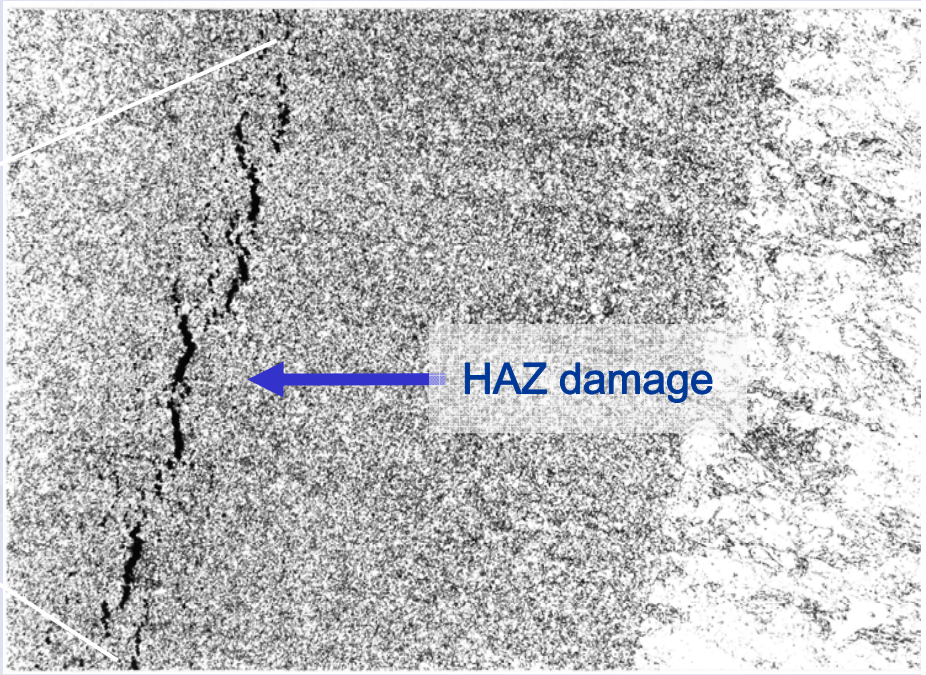
Type IV cracking





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VALID – the project

- £1.05m effort → £426k TSB grant (40.5%)
- About to start, 3 year duration
- Partners:
  - Air Liquide UK, Metrode,
  - Scottish & Southern Energy, Centrica Energy,
  - IGCAR
  - TWI

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Approach

- WP1 - Definition of industry and code / standard / regulatory requirements. Identify req's for fabrication and welding of new generation CSEFs and materials to be investigated.
- WP2 - Assessment of existign and advanced welding techniques and consumables
  - Mechanisable: TOPTIG®, AC SAW and narrow gap TIG
  - manual: MMAW and FCAW (reference, further development)
  - electrodes/filler wires and shielding gases: focused on low heat inputs
- WP3 - Technique Development: Determine ideal HAZ using low heat input EB welding and extensive creep testing

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Approach

- WP4 - Design and development, based on WP 2, for
  - electrodes, wires and fluxes;
  - welding process to minimise HAZ widths;
  - system control/monitoring hardware requirements for real-life fabrication.
- WP5 - Creep testing

  This will involve about 78 tests, with 30 tests of 8k-10k h duration.Sample preparation and testing fully funded by IGCAR and the Indian Department of Atomic Energy as part of their collaboration in this programme.
- WP6 - Develop library of welding procedures that can be applied to original fabrication and repairs of identified CSEF materials used in power station plant/components.

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