Success Story
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K-Projekt Network of Excellence for Metal JOINing
Programme: COMET – Competence Centers for Excellent Technologies
Programme line: K-Projects
COMET subproject, duration and type of project:
MS – Microstructure and mechanical behaviour of electron beam welded joints of 9-12% Cr steel, 09/2014 – 08/2018, strategic

Using the novel “Focus Wobbling” technique to supress the formation of hot-cracks in the fusion zone of a 9% Cr-steel

Content of this project is the investigation of the microstructure and the thermomechanical properties of a boron and nitrogen strengthened 9% Cr steel (NPM1). It has been revealed, that independent from the used parameters there is a formation of hot cracks in the fusion zone. By using a novel technique, which varies the focus position during the electron beam welding process, a significant reduction of accumulated area and length of hot cracks has been observed. Based on the hot-cracking optimized parameter configuration, single welds have been performed and creep tests have been started. After 2300h under high stress exposure, and temperature, there is no sign that small hot-crack formations in the fusion zone will have a major effect on the creep properties.

State of the art and definition of task

During the performed bead on plate welding, the boron and nitrogen strengthened 9% Cr steel revealed a serious cracking problem. Scanning electron microscope investigations classified the occurring cracks as hot cracks. A systematic variation of the welding parameters (beam current, static focus position and welding speed) led to no significant improvement with regard to the cracking problem.

An extensive literature research was conducted and a novel electron beam welding technique was found. A variation of the focus position during the actual welding process shows an improvement according to the hot-cracking of a nickel based alloy.

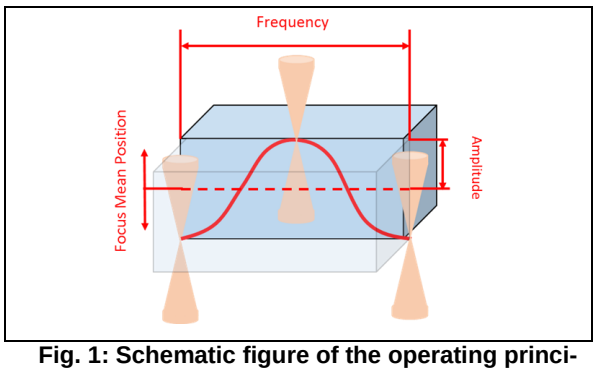

Fig. 1: Schematic figure of the operating principle “Focus Wobbling”

Definition of the task is the successful implementation of the “Focus Wobbling” technique to the electron beam welding facility at TU Graz, the investigation of the influence on the hot-cracking behaviour and to optimize the parameters with regard to the hot-cracking problem. Based on this optimized parameter set, creep tests with high stress exposure (130/150 MPa)

and service temperature at 650°C were be performed and the influence of the occurring hot-cracks on the creep properties are investigated.

Implementation "Focus Wobbling" technique and influence investigation

The novel so-called "Focus Wobbling" technique was successfully implemented to the electron beam welding facility at TU Graz for welding of 9% Cr-steel. Preliminary tests show the capability of this technique to supress the formation of hot-cracks.

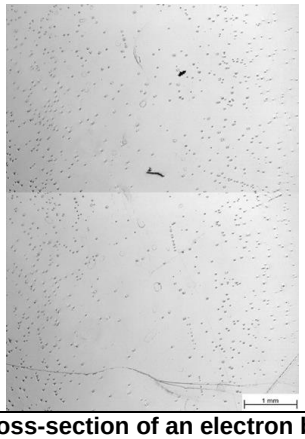

Fig. 2: Cross-section of an electron beam welded seam with dynamic focus position

To gain a better understanding a statistic variation of the relevant parameters (dynamic focus position, frequency and amplitude of the oscillation) and single welds with and without "Focus Wobbling" have been performed to quantify the influence of this novel technique. The evaluation was conducted according to the accumulated area, length and number of the occurring hot-cracks in the fusion zone.

It has been revealed, that with this novel technique and an optimized parameter configuration the accumulated area was significantly reduced.

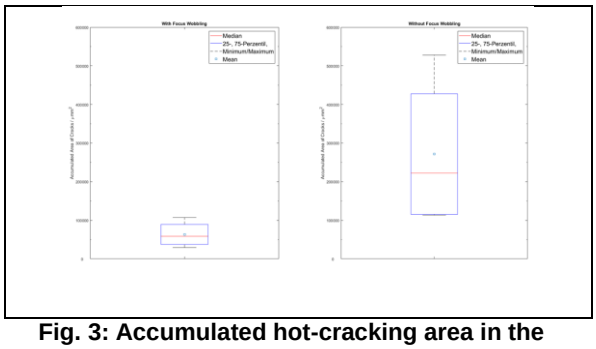

Fig. 3: Accumulated hot-cracking area in the fusion zone with (left) and without (right) "Focus Wobbling"

Impact and effects

The novel technique "Focus Wobbling" was successfully implemented to the facility of the TU Graz. An optimized parameter configuration with respect to the hot-cracking problem for a 9%Cr-steel and a welding depth of 50mm was found.

Based on the optimized parameters, creep tests with a high stress exposure and temperature were performed to investigate the influence of the remaining hot-cracks on the creep properties. After 2300h, there was no major influence of the remaining cracks on the rupture time observed.

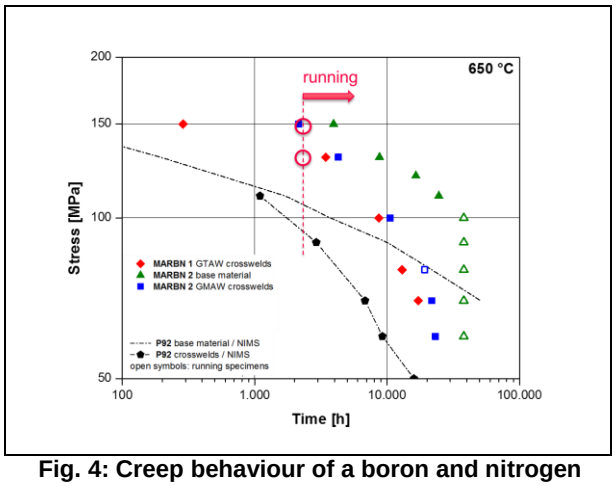

Fig. 4: Creep behaviour of a boron and nitrogen strengthened 9% Cr-steel

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