

metal JOINing

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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:**

**PS – Electron beam welding of 9-12% Cr steel (EBW), 09/2014 – 08/2018, strategic**

### Using a matched interlayer to enhance the hot cracking resistance of a 9% Cr steel

Content of this project is the investigation of the electron beam weldability of a boron and nitrogen strengthened 9% Cr steel (NPM1). It has been revealed, that independent from the used parameters there is a hot-crack formation within the fusion zone. Based on comparative bead on plate welding with comparable 9% Cr steel (P91/P92) and same parameter configuration, a fitted filler material for the interlayer was determined. Joint welds between the participating 9% Cr steels (NPM1-P91) with different dilution proved the positive effect and the suppression of hot crack formation with increasing amount of P91.



#### 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 investigation classified the occurring cracks as hot cracks. Systematic variation of the parameters improved the results according to accumulated area and length of the hot cracks. Nevertheless, it was not possible to avoid them completely. New focus to prevent the formation of hot cracks in the fusion zone lied on the selection of a fitted filler material for an interlayer and an optimized dilution.

Definition of the task was to perform comparative bead on plate welding with comparable 9% Cr steel (P91/P92) to verify the used parameter set and to investigate the suitability as a filler material with respect to suppressing hot-crack formation.

Joint welds (NPM1-filler material) with different dilution should detect a critical ratio between

NPM1 and a fitted filler material to ensure sound and crack-free welds for the future.



#### Comparative bead on plate welding and butt-welded connection

Comparative bead on plate welds for P91 and P92 with the same parameter configuration were performed. While P92 showed a similar hot-cracking behaviour to NPM1, it was possible to produce completely crack-free and sound welds with P91 (see Fig. 1).

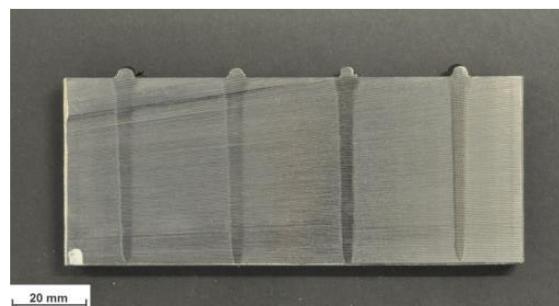
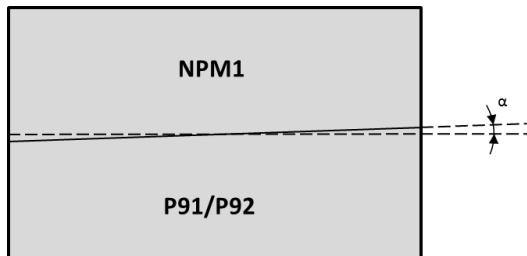


Fig. 1: Comparative bead on plate welds of a P91 to investigate the filler material suitability

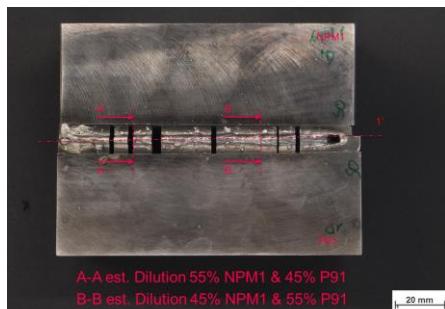
In the course of the comparative bead on plate welds the used parameter set has been verified and the suitability of P91 as a filler material has been proven.

Therefore, joint welds between NPM1 and P91 were produced. To get different dilution depending on the investigated position, the abutting face of the participating surfaces had a  $1^\circ$  angle (see Fig. 2).

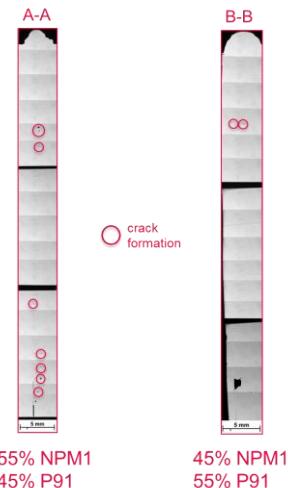


**Fig. 2: Schematic figure of a butt-welded connection between NPM1 and a P91**

To investigate the influence of different dilution on the cracking behaviour, different locations of the weld seam were observed. It has been revealed, that with an increasing amount of P91 there is an improved hot-cracking resistance. A ratio of 55% P91 and 45% NPM1 delivered promising results.



**Fig. 3: Joint weld between NPM1 - P91 with different dilution**



**Fig. 4: Cross-sections with different dilution joint weld NPM1 and P91**

### Impact and effects

Based on the performed investigations, the used parameter configuration was verified and a fitted filler material, which will be used as an interlayer, selected. The necessary interlayer thickness was detected due to a joint weld between NPM1 and P91 and it was revealed that at least an amount of 55% P91 is necessary to improve the hot-cracking behaviour in a significant way.

For the future, joint welds with different interlayer thicknesses (1.5mm / 60%P91, 2mm / 80% P91 und 2.5mm / ~100% P91) will be produced and characterized.

The performed experiments enable a fast selection of a fitted filler material and quantify a minimum interlayer thickness / dilution.

These findings delivered valuable information for further investigations. Thereby, a solid base for the solution of the hot-cracking problem of an electron beam welded boron and nitrogen strengthened 9% Cr steel was created.

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