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Welding of carbide-free bainitic steels for rail applications

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Background of Carbide-free bainitic steels for rails applications and welding concerns

In recent years, there has been a limited scope for the future development of pearlitic grades on railway applications, which is necessary due to its continuous advancement. For this reason, carbide-free bainitic steels were first developed during the late 90s [1], showing greater performance in some fatigue deformation mechanisms such as head checks, and high rates of wear resistance [2.3].

Nevertheless, as it can be observed from figure 1, problems are encountered when welding carbide-free bainitic grades in both Flash Butt (FBW) and Alumino Thermic (ATW) welding, which are the most common welding mechanisms used in the railway industry. Figure 1 shows severe wear, fatigue cracks, weld batter and corrugation in the rails head, leading to cracking and replacement of the weld [4].

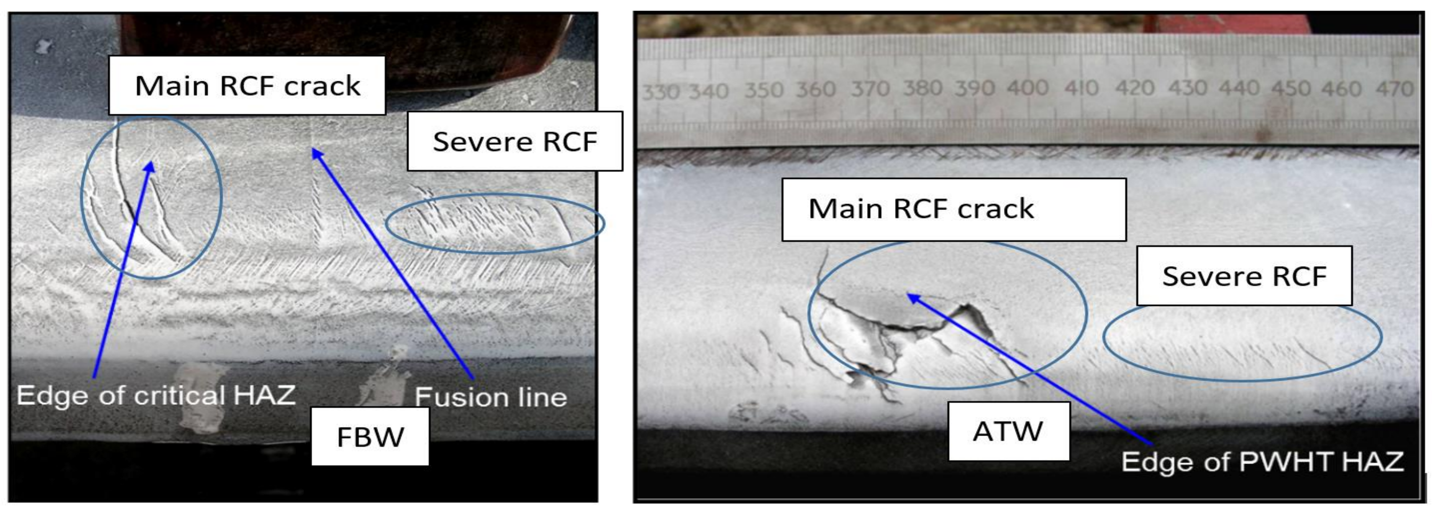

Fig 1. Cracks produced in the Heat Affected Zone (HAZ) of a carbide-free bainitic B360 grade (360HV) [3]

Project aims

- Understand the microstructural evolution of the HAZ of carbide-free bainitic grades.
- Study the most detrimental parts of the HAZ and its mechanical properties.
- Study a way of improvement the welding mechanism of carbide-free bainitic grades.

Methodology

A pearlitic R260 (260HV) rail was welded with a Carbide-free bainitic rail B360 (360HV) using a conventional Flash Butt Welding (FBW) procedure.

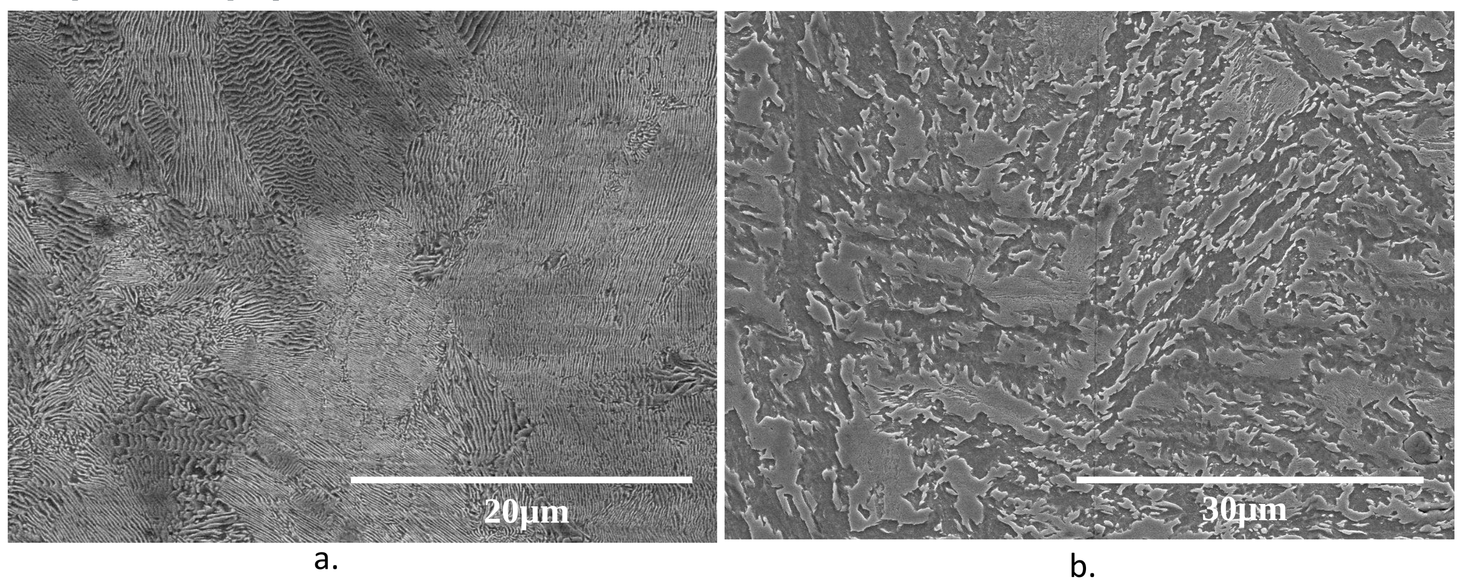

Fig 2. SEM examination of a. R260 and b. B360

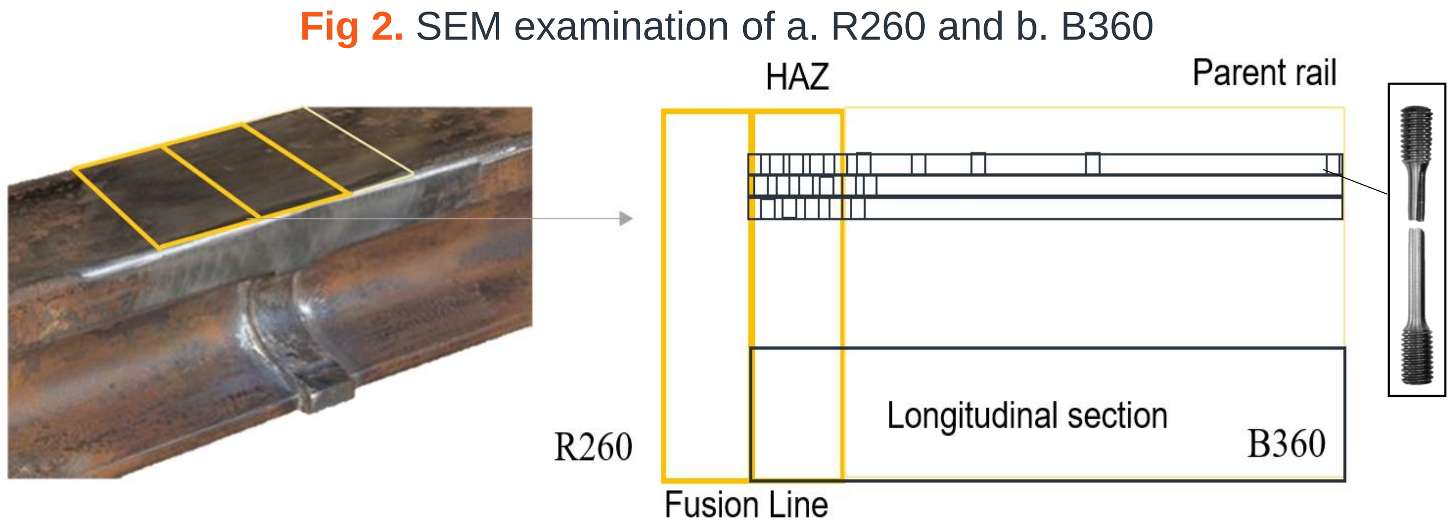

Fig 3. Schematic representation of the samples machined from the HAZ of a R260-B360 weld

- The longitudinal-vertical section was used for metallographic examination, indentation and Laser Induced Breakdown Spectroscopy (LIBS).
- The transversal samples were used for tensile test.

Results

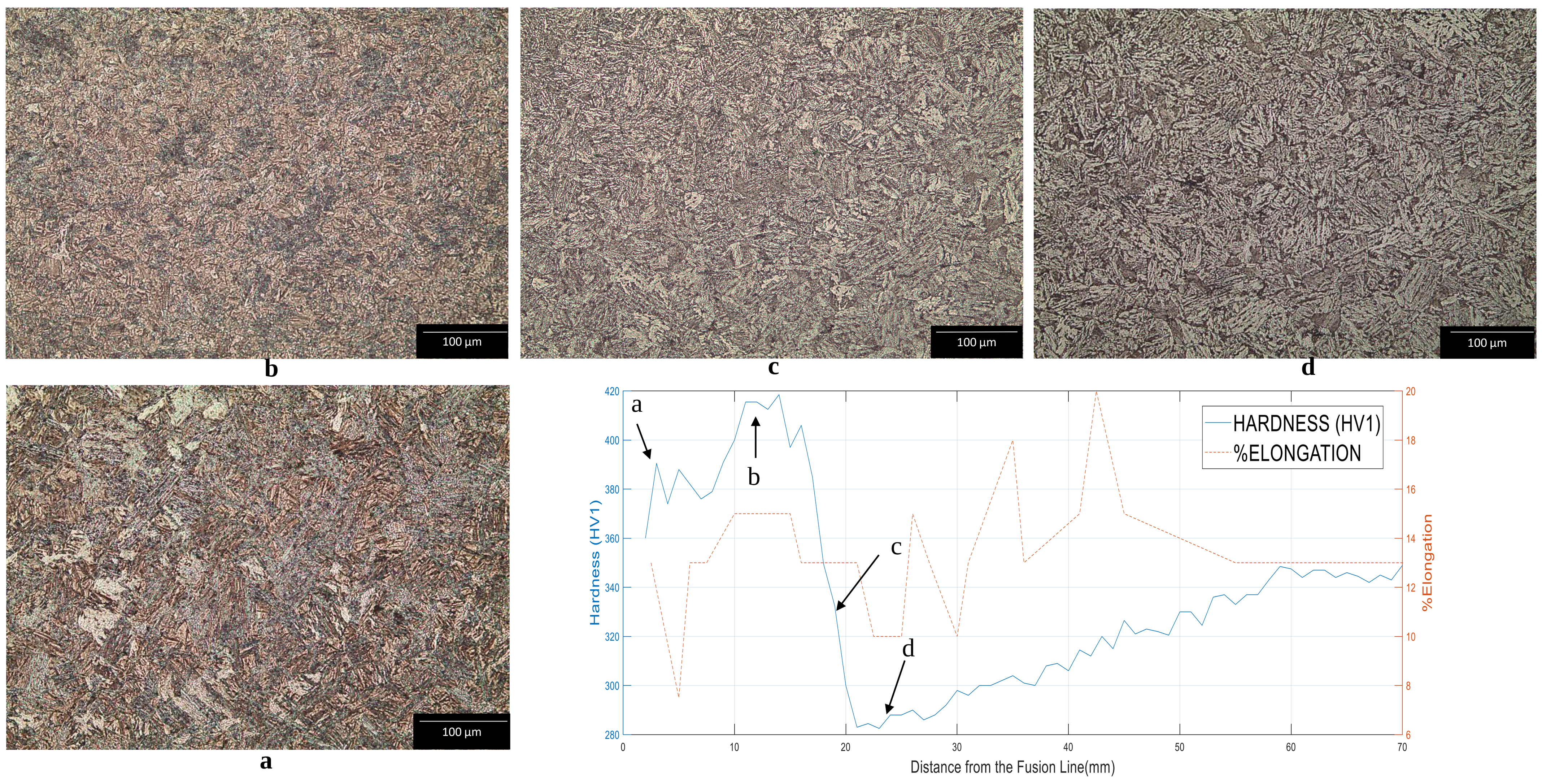

Fig 4. Results obtained from the longitudinal-vertical section of the weld. Hardness, %Elongation and metallographic examination

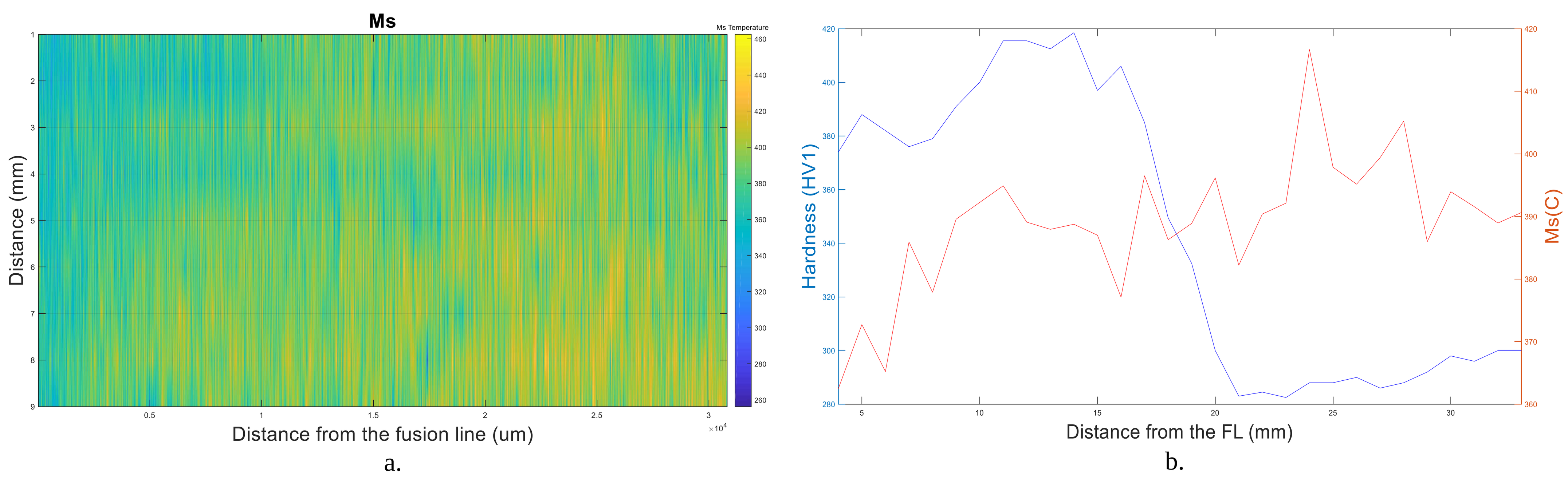

Fig 5. Spectroscopy measurements had permitted the calculation of the Ms temperature at different regions of the HAZ. a. Ms versus distance from the FL, b. Ms Versus hardness measurements

Conclusions

- High variations of hardness and %Elongation in all the HAZ (tempered bainite, martensite, retained austenite and acicular ferrite)
- Does not satisfy the minimum hardness criteria in the HAZ: P-94.5
- Lower values of %Elongation are found near the FL, which correspond with high values of hardness.
- Lower Ms temperatures correspond with high carbon martensitic regions and therefore, regions with higher hardness levels

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