Improving aluminothermic weld behavior through micro-structure and mold geometry modification

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Introduction

The trend in heavy haul railroad market is to increase rail hardness to reduce wear and improve track lifecycle costs. Also, changing traffic conditions have led the networks to desire more mechanically superior welds.

This study works on understanding the influence of critical welding parameters on the mechanical behavior of aluminothermic welded rail and looks to improve properties such as slow bend test results, optimized microstructure and overall weld integrity with minimal changes to current welding process..

Figure 1. Aluminothermic weld

Experimental work

We carried out most of the tests in our R&D facilities.

For each weld we tested the following:

- Non-destructive tests : Ultrasonic and Magnetic particle control
- Brinell Hardness test with 3000kg load and 10mm spherical indenter
- Chemical analysis with Optical Emission Spectrometer
- 4-point slow bend test, until rupture with a 300 tonne press

During the study, we tested different combinations of final weld steel chemistries and weld collar shapes.

Results

First step was to characterize the behavior of the weld steel Itself. For this, we realized welds with different chemical composition and ground the collar of the weld in order to remove the influence of the geometry.

Figure 2: Microstructure analysis

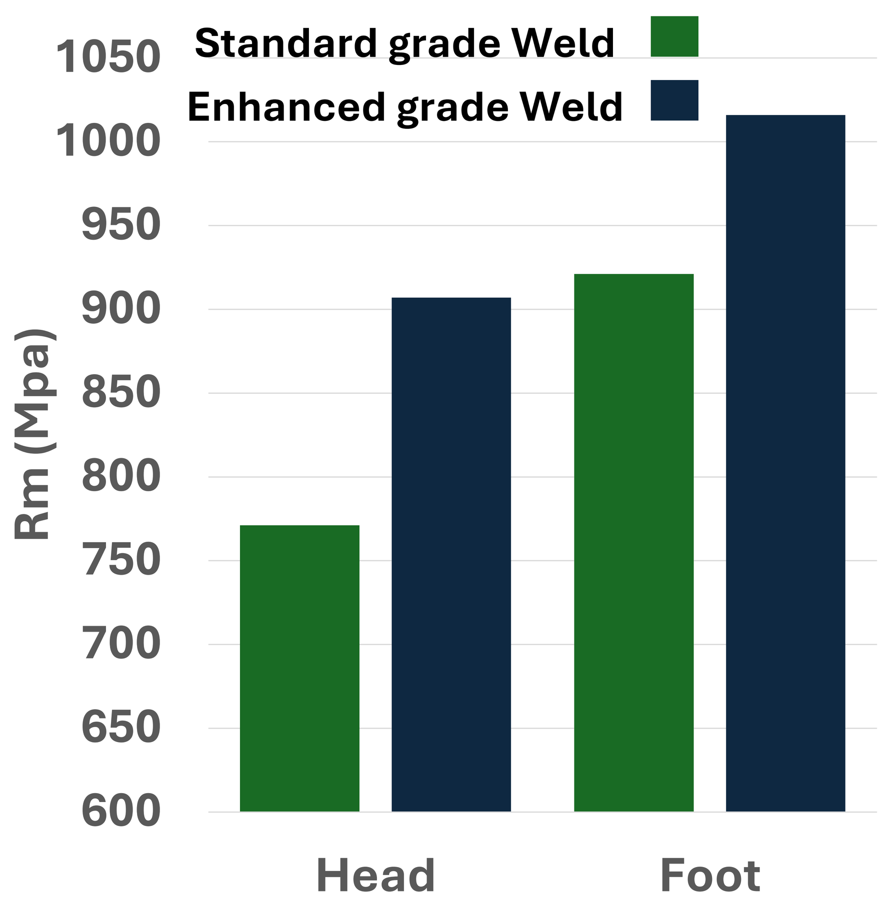

Figure 3: Tensile test results

Results were validated using tensile testing, carried out on samples taken from inside the weld. (Figure 3)

These tests confirmed that a presence of uniformly dispersed isolated islands of martensite inside the pearlite matrix, increases the mechanical properties of the steel. This structure is similar to the dual phase structure (Martensite-Ferrite structure) observed in the automotive industry applications (Figure 2)

Second step consisted of finding the best geometrical configuration for the weld collar.

- First idea : Create a collar which follow the shape of the fusion zone.
- Second idea : Smoothen the junction with the rail to reduce the stresses on this area.

Analysis of 4-point slow bend test results with the latest configuration showed that this enhanced process has good and stable results (Figure 4).

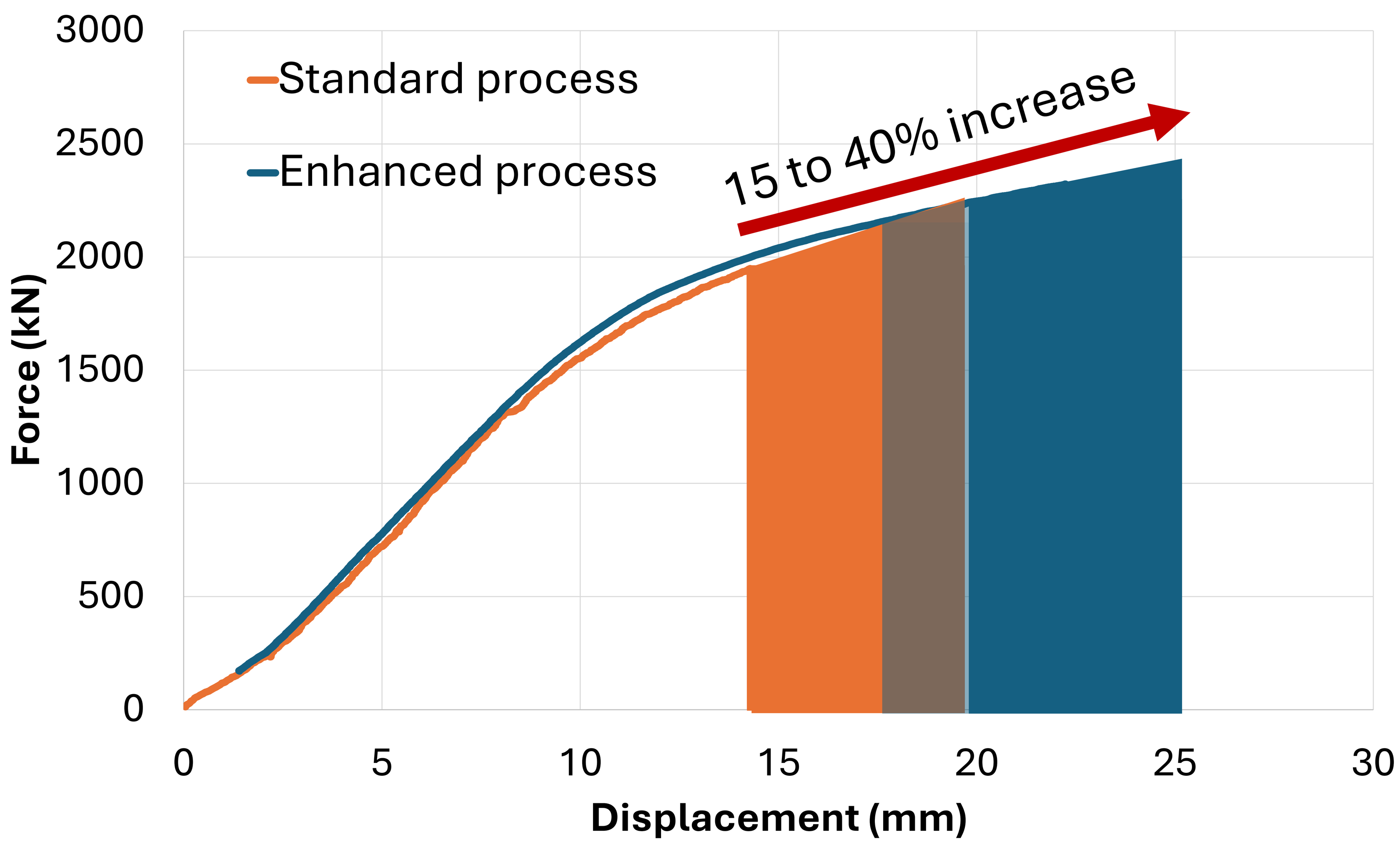

Figure 4: Slow bending test results

Conclusions

Having a small amount of martensite inside the pearlite matrix improves the mechanical properties of the steel produced through the ATW process.

Combine this with a modification of the collar shape, It leads to a major improvement of the aluminothermic weld behavior during slow bend tests.

This new ATW process will be tested in external labs in 2025-2026 in order to be proposed to all rail networks.

References

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