INNOVATIVE TESTING OF RESIDUAL STRESS OF RAILWAY WHEELS

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Introduction

A key challenge in the manufacturing of railway wheels is controlling residual stresses in the rim to minimise the risk of crack initiation. This is typically achieved through heat treatment, which induces a compressive circumferential residual stress field within the wheel rim. While the traditional saw-cut method is widely used to assess residual stresses, it yields only qualitative results. In contrast, the strain gauge method quantifies residual stress by measuring its progressive release during a series of precise cuts.

This study investigates the effectiveness of using waterjet cutting as an alternative method for making the cuts required in the strain gauge method.

Experimental work

As specified in BS EN 13262 (2020) and shown in Figure 1, the residual stress near the tread surface should fall between 80 N/mm² and 150 N/mm², gradually reducing to zero at a depth of 35 mm to 50 mm below the rolling contact line. Using the guidelines of BS EN 13262 (2020), strain gauges were strategically placed on the wheel rim (Figure 2). While abrasive cutting is typically employed in the strain gauge tests, this study introduced waterjet cutting for the primary cuts to minimise heat input (Figure 3) - an innovative approach for railway wheels. To ensure accurate measurements, the strain gauges were carefully sealed to minimize the effects of water exposure. Following the initial waterjet cuts, the rim was cut in stages using a belt saw. This progressively released the residual stresses, and changes in the residual stress state were evaluated by taking strain readings after each cutting stage.

The results from the waterjet-based method were compared with the results from an independent laboratory, which applied the conventional abrasive cutting and the strain gauge method on a wheel from the same production batch.

Results

The results from the water jet cutting showed a maximum residual stress of -299 MPa at the surface, with zero stress observed at a depth of 65 mm. The results from the independent laboratory indicated a circumferential stress of -184 MPa at the surface and a zero stress at a depth of 89 mm. Both test values fell outside the limits specified by BS EN 13262 (2020) and the results are shown in Figure 4.

These findings highlight significant variations between the two testing methods in residual stress measurements. The discrepancies between the results and the BS EN 13262 (2020) standards raise important questions about the current manufacturing processes and the potential need for re-evaluation of existing standards. The differences in stress values and zero stress depths also emphasize the importance of standardized testing procedures in the industry.

Conclusions

The study demonstrates that waterjet cutting could be a viable method for future testing of residual stresses in rail wheels. Both test results showed similar deviations from BS EN 13262 (2020), suggesting the potential of alternative technologies in evaluating circumferential residual stresses. Both tests showed that the wheel does not satisfy the requirements from BS EN 13262 (2020), suggesting that waterjet cutting could be a viable method for future testing.

This study underscores the potential of alternative technologies in evaluating circumferential residual stresses in railway wheels. It demonstrates that non-traditional methods can yield favourable results and recommends further exploration of alternative cutting techniques for future applications. The research recommends further exploration of alternative cutting techniques to improve the accuracy and reliability of residual stress measurements in railway wheel manufacturing.

References

BS EN 13262, 2020. Railway application. Wheelsets and bogies. Wheels. Product requirements. London: BSI

Acknowledgments

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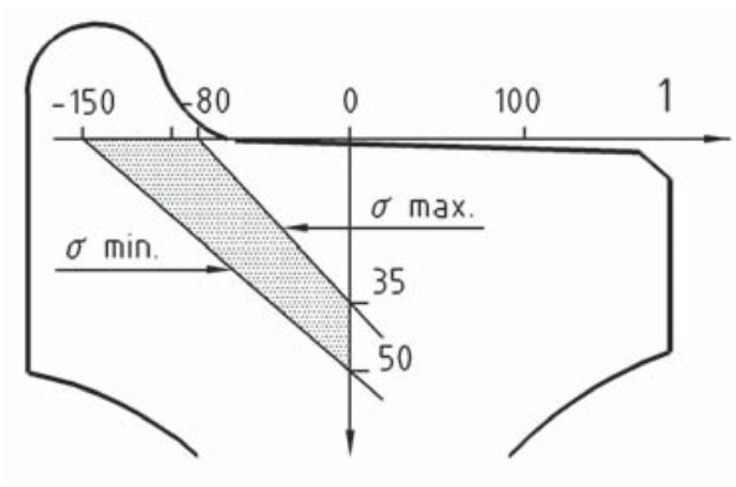

Figure 1: Range in variation of circumferential stress values (adopted from BS EN 13262 (2020))

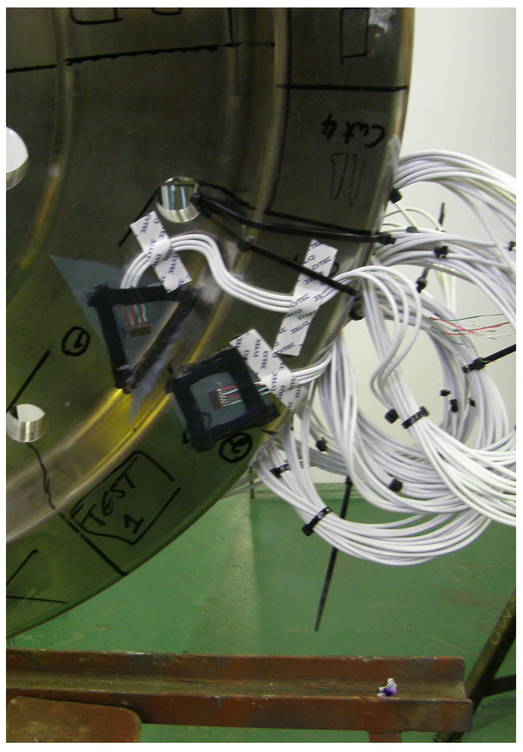

Figure 2. Placement of Strain gauges on railway wheel

Figure 3. Waterjet cutting of wheel rim

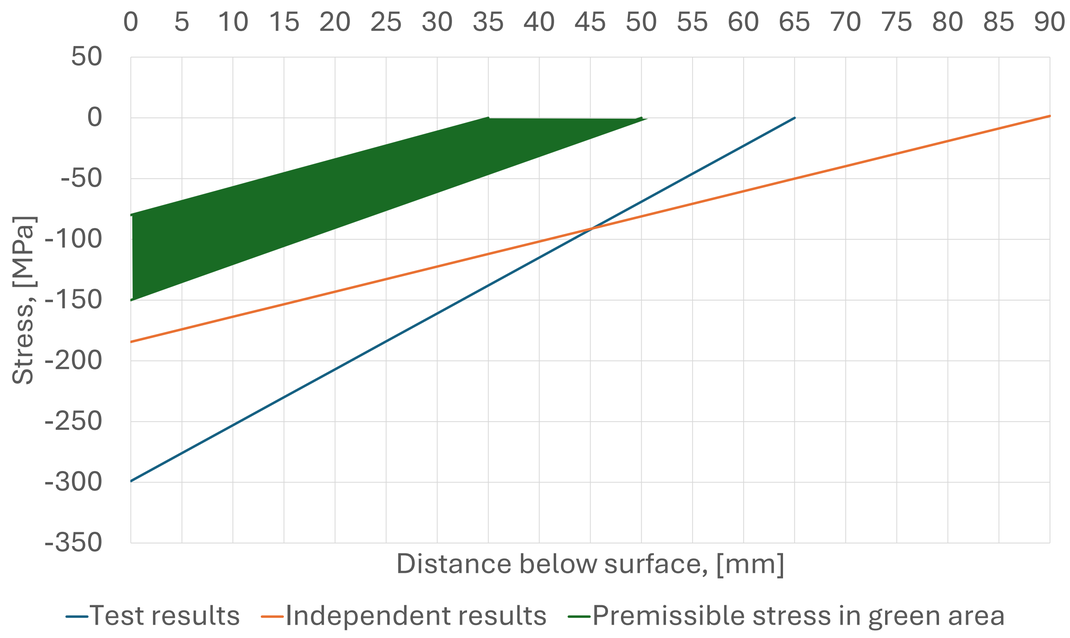

Figure 4: Permissible and measured residual stress

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