ISSN: 3066-814X
Research Article
Journal of Clinical Dentistry and Oral Care

Analisis Properties of The New Produced Welded Parts – Regulated Spindels

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Submitted: 20 May 2025 **Accepted:** 26 May 2025 **Published:** 30 May 2025

https://doi.org/10.63620/MKJCDOC.2025.1034

Citation: *Jashari, N., Cvetkovski, S. (2025). Analisis Properties of The New Produced Welded Parts – Regulated Spindels. J Clin Den & Oral Care, 3(3), 01-06.*

Abstract
This research work concerns to investigation properties (fitness for purpose) of new produced welded parts. Besides scientific this paper has practical meaning too. Investigations was prepared on the request of the Company MZT WABTEK AD, Skopje that produce and build in parts for railway vehicles. Subject of investigations are two new produced (non-used) welded parts named regulating spindles. These regulated spindels were produced by welding company i.e. subcontractor.

Two delivered, new regulating spindles were tested to check their properties, mechanical and microstructural. Based on request from purchasers, the following testing were performed:
- *Visual Inspection;*
- *Tensile testing;*
- *Determination of non-metallic inclusions;*
- *Macro and micro metallography;*
- *Hardness measurement*

The results of performed testing were analyzed in detail, and the following opinion about the quality of new manufactured regulating spindles is given: Presented investigations of the new produced spindles were performed in order to check their quality before implementation in exploatation conditions. More concretely the quality of ERW (Electro Resistance Welding) was checked. It was concluded, from the performed investigations, that properties of the investigated spindles are in accordfance with standard requirements. So the spindles can be implemented in the exploatation if all of them have the same quality as the two investigated spindles.

Keywords: Electro Resistance Welding (ERW), Microstructure, Heat Affected Zone (HAZ), Regulating Spindle, Steel S355J2C+C, Visual Inspection, Mechanical Properties, Non-Metallic Inclusions

Introduction

This research work concerns to analysis of performed investigations in order to check quality of new produced welded parts. More concretely investigations have to show (fitness for purpose) of new produced welded parts. These spindles will be subjected to work in different weathering conditions and different types of stresses. Could these parts to be built in railway vehicles, will be confirmed by the performed investigations. Investigation was performed on the request of MZT WABTEK AD, Skopje, company that produce and build in parts for railway vehicles. Subject of investigations are two new produced (non-used) parts known as regulating spindles. Performed investigations, mechanical and microstructural showed that welded joints have required quality.

Delivered regulating spindles were subjected to different testing in laboratory for metallographic and mechanical testing. Based on this request, the following testing were performed: visual inspection, tensile testing, determination of non-metallic inclusions, macro and micro metallography and hardness measurement. The results of performed testing were analyzed in detail, and the following opinion about the quality of new manufactured regulating spindles is given: Presented investigations of the new produced spindles were performed in order to check their quality before implementation in exploatation conditions. It was concluded from the performed investigations of the tested spindles are in accordance with standard requirements. So the spindles can be implemented in the exploatation if all of them have the same quality and fulfill necessary properties.

Base Material and Used Welding Process

Base materials used for electro resistance welding (ERW) of regulating spindles are given in the table 1.

Table 1 Parts of welded joints used for production regulating spindles

Feature	S355J2 part1	S355J2C+C part 2
Standard	EN 10025-2	EN 10277
Form	Hot rolled	Cold drawn

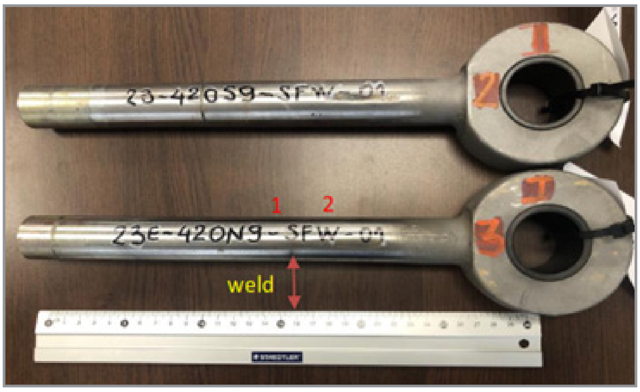

Figure 1: Welded regulating spindles

Mechanical Testing – Tensile Testing

One of the investing spindles was used for tensile testing. It was used as technological testing probe. It means that regulating spindle was put in tensile testing machine and subject to tensile testing. Results of tensile testing of spindle is given in the table 1. Obtained values for tensile testing fulfilled standard requirement for this type of steel. It can be seen that elongation of the spindle is more than 23.3 %.

Table one Mechanical testing of spindle

Sample tag	Rp0.2 N/mm2	Rm N/mm2	A%	Load KN
S355J2	355	510-630	22	-
23E-420N9-SFW-01	392	531	23.3	375

As can be seen from the figure 2, the spindle was fractured in the base metal, out of welded joint which is required during testing. It confirmed too that welding process was performed properly. Figure 2b show fractured surface of the tested spindle. Typical cup and cone fracture can be seen. It obvious that plastic deformation during testing appeared [5].

Figure 2: Fractured spindle after tensile testing

Metallography

For the metallographic investigations were prepared specimens cut from the welded joint of investigated spindle. Transversal surfaces of the weld was prepared. Standard metallographic preparation of the specimens was done. After grinding and polishing with alumina suspension, nital (3%) etching of the specimens was done. Macro and micro analysis of the prepared specimens were performed.

Determination of Non-Metallic Inclusions

Polished metallographic specimens were used for the analysis of the material cleanliness i.e. presence of non-metallic inclusions. Magnification of x100 was used. Figure 3a represent content of non-metallic inclusions in the part1 of the spindle, and figure 3b represent the content of non-metallic inclusions in the part 2 of the spindle. Very similar content of inclusions in all specimens is noticed. Mainly sulphide type of inclusions are present. Anyhow, both materials are very clean concerning presence of non-metallic inclusions.

Figure 3 (a and b) Non-metallic inclusions in the both parts of the spindle

Macro-Metallography

Figure 4 presents macro-photo of the metallographic specimen (spindle welded joint). Etching of the specimen was made with Nital. It is clearly seen from the metallographic specimen that welded joints is regularly formed. Non-alloyed defects were not detected. From both sides of the weldment are formed HAZ (Heat Affected Zone). After that base metal can be seen too [6-7].

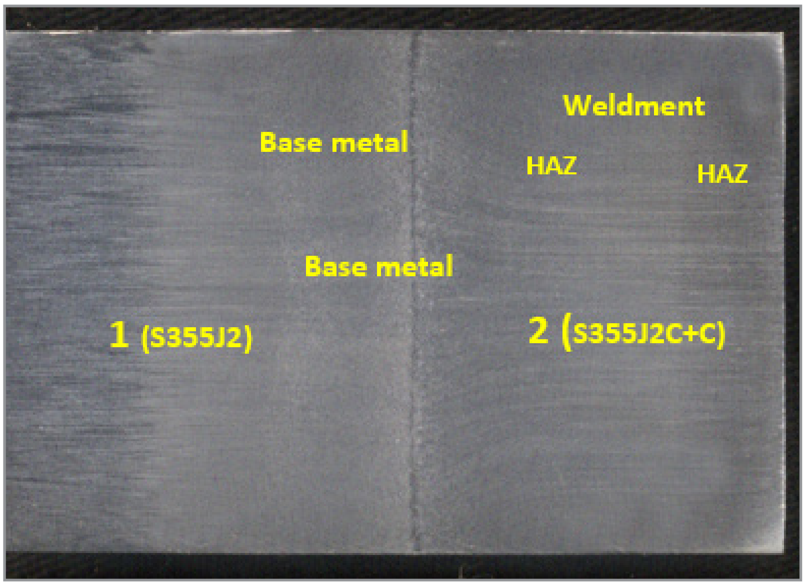

Figure 4: Macro-photo of metallographic specimen

Micro-Metallography

Microstructure of the investigated regulating spindles is shown at the figures 5 and 6. Different i.e. x50, and x100 were used. Magnification of part 1, figure 5 is x50. Magnification of part 2 is x100. Characteristic microstructures of the welded joints are presented on these pictures. Microstructure of base metal of parts 1 and 2 of the welded joints is manly ferrite-perlite. Ferrite is dominating microstructure, because base material is low alloyed steel. Typical banded microstructure can be seen, figure 5a and 6a. It is characteristic for steel with high manganese content, about 1.6% in this case. It has to be point out that part 2 have finer microstructure because it is cold rolled. Coarse-grained HAZ consists of coarse polygonal grains, which are delineated with ferritic bands. Inside the grains, there is needle like microstructure, mainly bainite (figures 5b and 6b). Besides fusion, line is clearly visible in both cases. In addition, microstructure of fine-grained HAZ is shown in the pictures 5c an 6c.

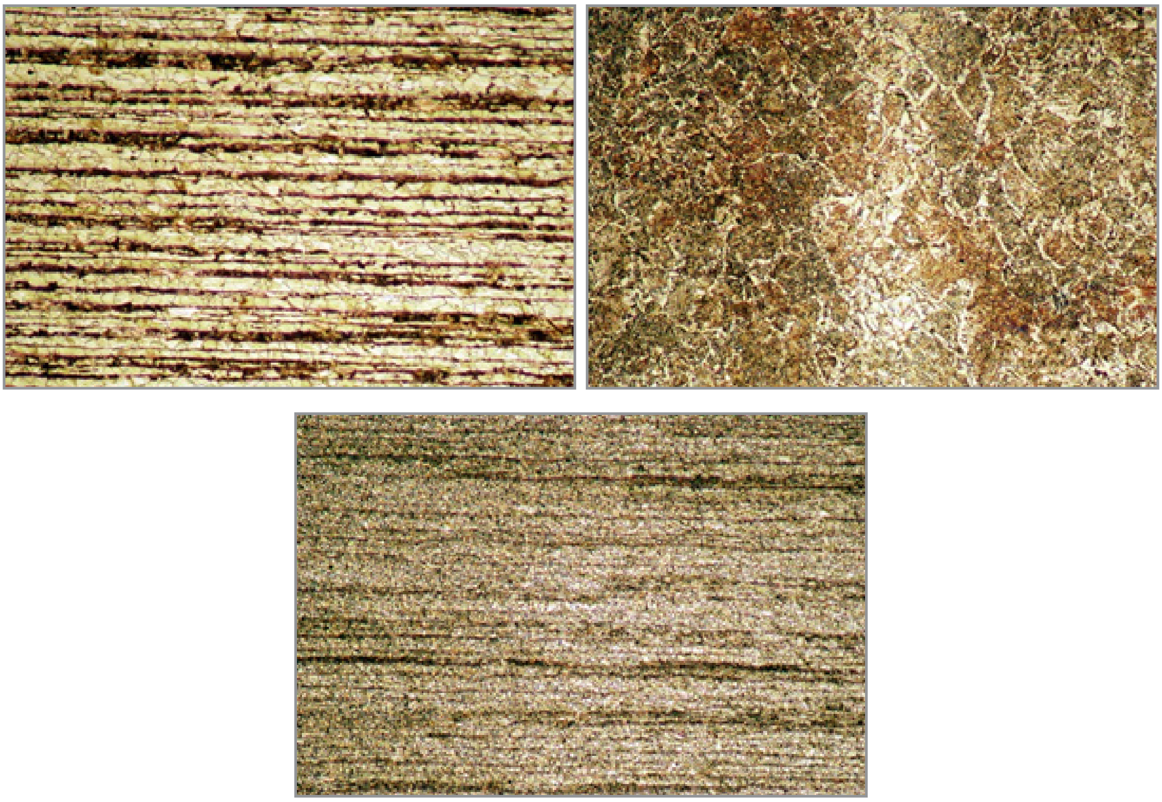

Figure 5: A Base Metal, Part 1, B Weld Metal And Haz, C Base Metal Part 2 (a-c) x50 Microstructure of the welded joint part 1

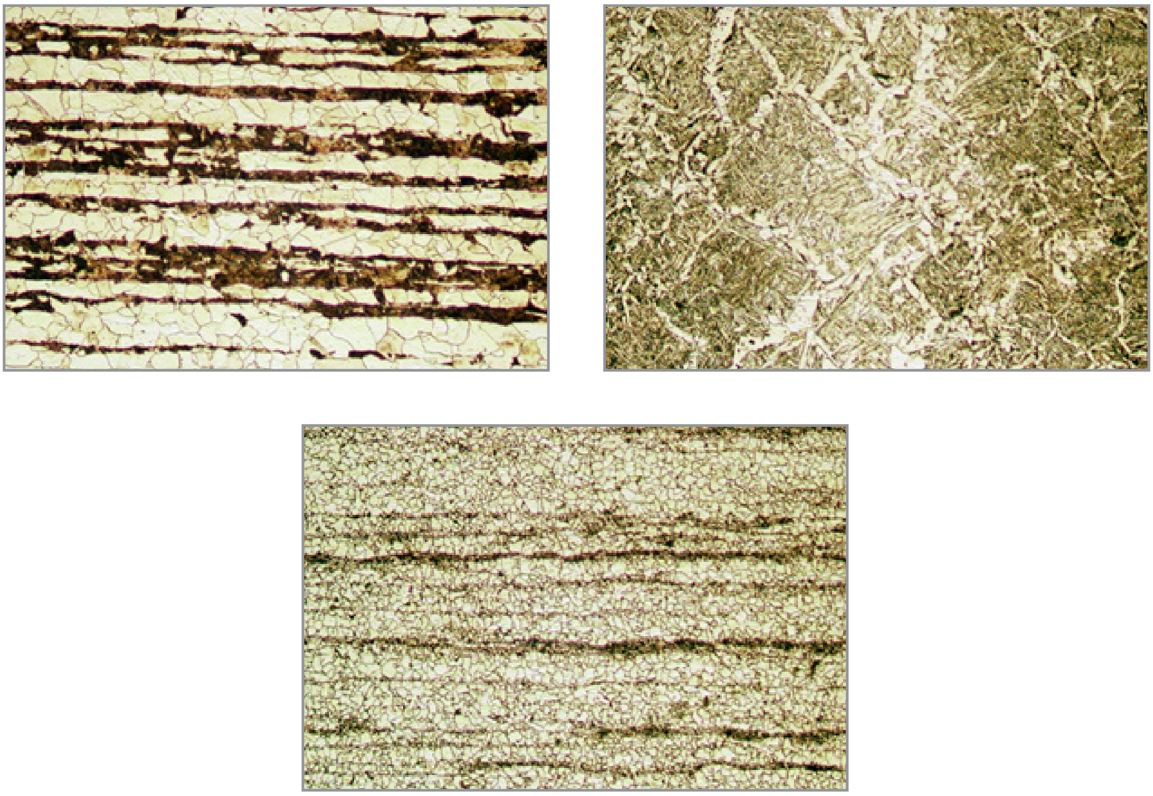

Figure 6: (a-c) x100 Microstructure of the welded joint part 2, a base metal, part 2b weld metal and HAZ, c base metal part 2

Hardness Measurement

Hardness measurement was performed along the welded joint itself, figure 7. HRB method of measurement was used. Besides, conversion from HRB to HB hardness was made too (Table 2).

The highest hardness has weldment itself. As can be concluded that part 1 S355J2 has lower hardness than part 2 S355J2C+C, which is cold rolled. Anyhow, obtained values are acceptable for this type of steel [8].

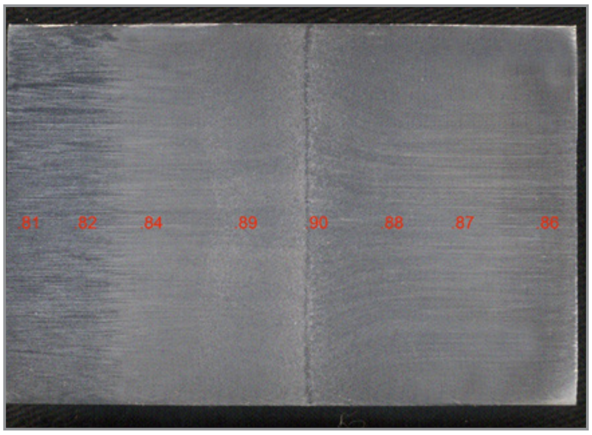

Figure 7: Hardness across the welded joint

Table 2 Conversion hardness from HRB to HB

HRB	HB
81	149
82	152
84	159
89	174
90	179
88	173
87	170
86	167

As can be seen from the table measured HB hardness values are are in the range 149 -179 which coresponds with standard requirement.

Discussion

Presented investigations of the new produced regulating spindles were performed in order to check their quality before implementation in exploatation conditions as a parts of railway wehicles. About it, selected spindless were subjected to visual inspection, metalographic investigation (determination of non-metallic inclusions, macro and micro metallography) and tensile testing. Visual inspection and confirmed that there is no any defects on the suraface of the investigated spindless. It can be said that parameters of electroresistance welding were properly chosen. Metallographic investigations confirmed that raw material is very clean concerning presence of non-metallic inclusions. Low number of elongated were found. Microstructure of base materials is is typical banded ferritic-perlitic microstructure. It is typical for steel with higher manganese sontects i.e. 1.6% in this case [9].

Tensile testing confirmed that properties of the spindles are in accordance with standard requirement. Elongation is 23% and Yield strength is Tensile strengths are higher than base material. Fracture of the spindle was out of the welded joint (weldment). Type of fracture is tupical cup and cone.Hardness values across the welded joint are in accordance with standards (140-192 HB) requirement .

Conclusion

From the performed investigations was concluded that properties of the investigated spindle are in accordfance with standard requirements. So the spindles can be implemented in the exploatation if all of them have the same quality.

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