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THE CASE OF UNSUCCESSFUL REPAIR WELDING OF A TREIBER ROLL

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Abstract: *Presented in this paper is the case of unsuccessfully performed repair welding of the upper treiber roll in the „Topla Valjaonica" facility within the Železara Smederevo, currently known today as Hesteel ltd. Inadequate and improperly performed welding technology resulted in the occurrence of a large number of cracks, with the possibility of their propagation to the parent material. The upper and lower treiber roll are parts of the installation whose purpose is to fold the rolled strip and then send it to be further machined. The parent material used for the upper treiber roll was the structural steel S235JO. Repair welding was the consequence of damage that occurred during the exploitation of the roll. Shown in the paper are some of the cracks detected on the welded surface of the upper treiber roll. The analysis of the reasons behind the occurrence of these cracks is presented, and machining was recommended for the purpose of removing of these cracks, along with the use of certain NDT methods.*

Key words*: repair welding, cracks, preheating, welding*

1. INTRODUCTION

Welding and activities related to it represent a process which requires special attention, starting from the design stage, through the development and performing of the technology and up to welded joint control stage, for the purpose of putting the welded or repaired machine part in exploitation. Deviations that occur during each of these stages may result in defects, cracks and deformation due to rapid cooling, along with the occurrence of unwanted metallurgical structures. Welding should be performed entirely in accordance with the welding technology. Presented in this paper is the case of repair welding of the upper treiber roll in the „Topla Valjaonica" facility within the Železara Smederevo. The upper and lower treiber roll are the driving rolls which are placed in front of each strip coiler. These rolls are used to fold the strip supplied by the output rollers and direct it towards the coiling mandrel. The upper treiber roll is supported by the driver switch cradle. In addition, the treiber roll serves the purpose of providing sufficient tensile force to the strip between the rolls and the coiling mandrel. . The diameter of the upper treiber roll is ∅900 mm, its calibrated length is 2280 mm, whereas the lower roll diameter is ∅400 mm. The geometry and position of the treiber rolls is shown in figure 1.

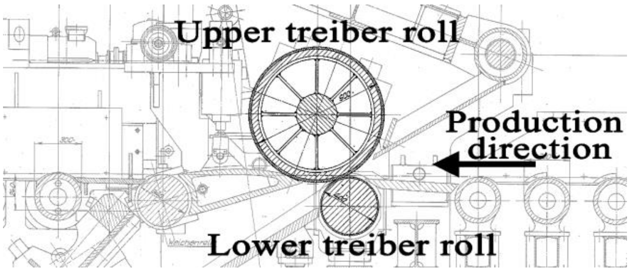

Fig.1: Position and geometry of the upper treiber roll in the production line

Due to exploitation conditions and wear, it was necessary to repair weld the upper treiber roll, as was predicted by the manufacturer. The roll was pre-machined in the mechanical workshop at the Železara Smederevo, to a diameter of ∅870 mm. After machining, magnetic flux testing of the whole roll was performed (including the branch and the work surface). The thickness of the welded hard layer should be up to 40 mm, including the intermediary layer, i.e. the diameter of the roll should be ∅910 mm. After welding and applying of hard weld layer, the upper roll have to be machined to a diameter of ∅900 mm. The following section of this paper contains a detailed overview of all activities performed during welding, as well as the activities performed in order to remove cracks. Repair welding was unsuccessful, resulting in the occurrence of cracks after cooling.

2. PROPERTIES OF THE UPPER TREIBER ROLL PARENT MATERIAL

The parent material of the treiber roll was steel S235JO, a general purpose structural steel with good weldability. Depending on the manufacturing process, chemical composition and relevant application, further letters and classifications might be used to reference particular grades/products of structural steel. This structural steels are used in many ways and their application can be diverse. They are particularly useful because they offer the unique combination of good welding properties with guaranteed strengths. Structural Steel is an extremely adaptable product and is often favored by the engineer trying to maximize strength or s structure while minimizing its weight [1, 2].

The chemical composition of the roll parent material is given in table 1, whereas table 2 shows its mechanical properties.

Table 1: Chemical composition of the roll parent material

Chemical Element	C	Si	Mn	Cr	Ni	Cu	P max	S max
%	0,17	0,3	1,4	/	/	Max 0.55	0,045	0,009

Table 2: Mechanical properties of the roll parent material

Mechanical properties	Tensile strength R_m [N/mm^2]	Yield strength R_e [N/mm^2]	Elongation	Toughness
Values	400-490	245	22	27

It should be noted that steel S235JO does not have the tendency towards neither hot nor cold cracks.

3. WELDING TECHONOLOGY

Repair welding was performed using automated FCAW procedure, with the following additional materials.

- WLDC 9 wire, along with the universal Weldclad powder was used for the puffer layer. This wire is low alloyed flux-cored wire, used for submerged-arc welding for build-up, maintenance and repair. WLDC 9 has excellent hot slag release, especially suitable for continuous welding operations. Universal Flux is suitable for single and multi-pass welding using single or twin wire technique [3].
- For the hard weld, WLDC 17 wire was used. This wire is fully basic, all mineral, non-alloying agglomerate flux for submerged arc welding wire, used for multilayer surfacing of hot strip mill process rolls including wrapper rolls and has a martensitic matrix [3].

First two layers formed the intermediary layer (puffer), whereas the following three layers represent the hard weld. Layers were applied using the oscillation technique, with weld overlap of 30-35%. Welding parameters are given in table 3. The diameter of the roll after surfacing is ∅ 910-912 mm.

Table 3: Welding parameters

Layer	Wire	Temperature max	Amperage	Polarity
1	WLDC 9	420 °C	500 – 550 A	-
2	WLDC 9	420 °C	500 – 550 A	+
3	WLDC 17	420 °C	500 – 550 A	-
4	WLDC 17	420 °C	500 – 550 A	+
5	WLDC 17	420 °C	500 – 550 A	+

The roll was not annealed after the repair welding was complete. Cracks have occurred in certain zones. These cracks where grooved by a grinder after surfacing, and it was determined that they cannot be eliminated, along with the assumption that they propagated into the pre-machined parent material. Shown in figure 2 are some of the cracks (along with the grooved ones), with designated fields (A to G).

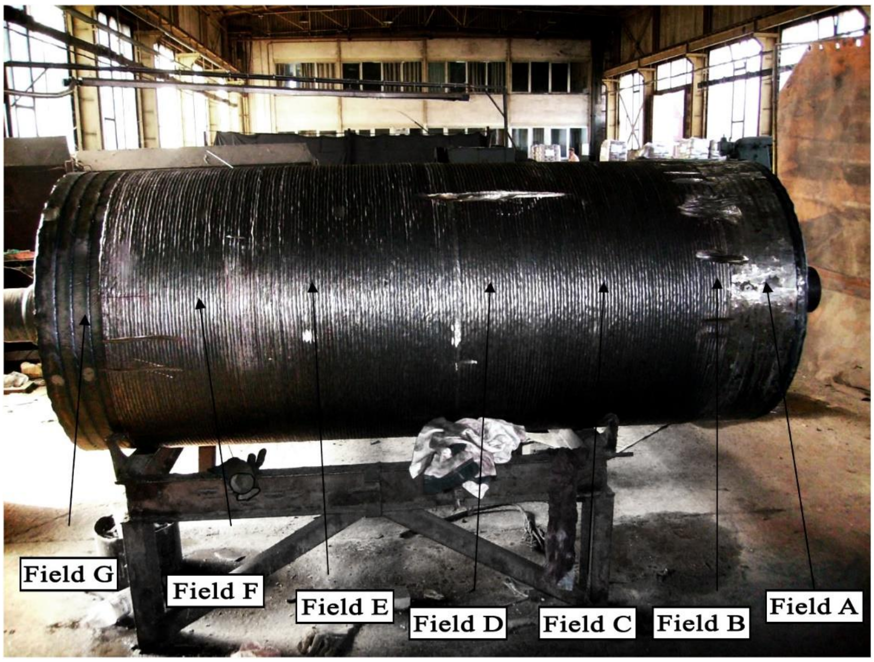

Fig.2: Appearance of treiber roll after repair welding

4. INSPECTION AND CRACK IDENTIFICATION

A total of 46 cracks were detected in the treiber roll after applied repair welding procedure. In addition to these cracks, a number of small mesh cracks were observed in field A, along the full circumference. For the purpose of easier identification, cracks were divided into zones, denoted A to G. Some of these cracks are shown in figure 3.

Field A was ground with a width of 300 mm along the circumference. Small mesh cracks were detected by magnetic flux testing in this field. Field B was 200 mm wide and grooved along the circumference. A total of 19 cracks were detected in this field. Two of the cracks were eliminated by grooving, to a depth of 20 mm. The depth to which the cracks have propagated could not be accurately determined, since there is no documentation about it. Field D, with a width of 300 mm, contained 13 cracks along its circumference. One of the cracks shown in this field was eliminated by grooving to the depth of 25 mm. The depth to which the cracks have propagated could not be accurately determined. Field F was 200 mm wide, and 14 cracks were detected along the circumference, some of which were eliminated by additional grooving, whereas some were not. No cracks were detected in fields C, E and G.

Fig.3: Some of the cracks on the treiber rolls after the surfacing

5. DISCUSSION AND CONCLUSIONS

Cracks have occurred as the result of a lack of preheating, i.e. due to cold surfacing of grooved locations. The cracks ere caused by applying the hard weld to an insufficiently preheated, or completely cold surface, even though the welding technology specified that preheating is mandatory. Most of the cracks were located in the reinforced part of the roll, as well as its vicinity. It is well known that parts with thickness greater than 20 mm must be preheated and this is recommended for properly performing welding procedure [4-6].

The treiber roll with defects shown in the previous parts of this paper could not be put back into exploitation. Thus, it is recommended to develop the plan for machining of the welded roll for the purpose of removing of cracks and defects. Due to welded layer thickness, it can be concluded that the operation of removing the whole weld for the purpose of determining of the extent of crack propagation, must be performed in several passes. It is recommended to perform testing using NDT methods on the surface following the removal of each layer, for the purpose of determining the crack depth. It cannot be claimed with certainty that the cracks have propagated into the parent material, since additional crack grooving was performed in order to eliminate them.

In this paper, the significance of preheating prior to repair welding for the purpose of avoiding crack initiation and other types of deformation can be seen. Preheating reduces the cooling rate, which in turn reduces the temperature difference between the cold parent material and the welded layer (which transforms from molten hot phase to a solid phase during the cooling, until the environment temperature is reached).

In addition to technical consequences, this also resulted in economic losses due to additional machining of the treiber roll after welding for the purpose of removing of defects, along with the need for repeated welding.

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