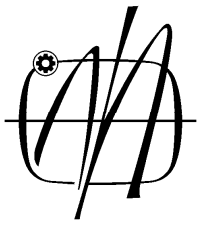

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Reparation of Steel Construction of Vehicle-mounted Self-propelled Crane's Telescopic Boom

In this paper it is presented reparation of steel construction of self-propelled crane telescopic boom by welding. By doing visual inspection of self-propelled crane, it is noticed numerous cracks and deformations at the outer and inner surface of steel construction at base metal and weld, both. Based on results of examination, it is decided to do reparation by welding in order to reduce influence of residual stresses.

Keywords: *repair, welding, filler material, auto crane, low alloyed steel.*

1 INTRODUCTION

This paper describes the reparation of steel structures for boom of self-propelled cranes TADAHO TL 200 II / K with capacity of 95t. The construction of crane consists of a motor vehicle and boom. Boom is made of profiles with rectangular cross section and can be extended telescopically. Operating device is placed at the end of telescopic boom. Boom mechanism is hydraulically driven and folds into transport position so that it is coaxial with the longitudinal axis of the vehicle and does not exceed the vehicle dimensions [1-3]. The steel structure of the boom is assembled, among the other methods, by welding. Each weld joint, no matter how well is performed, is by its nature a discontinuity in the material or place of local geometric and microstructural inhomogeneity. It makes the weld joint a possible place of occurrence of initial cracks. Cracks act as stress concentrators and make the working load locally overcome the critical stress which leads to failure during the exploitation [4, 5]. During non-destructive tests of self-propelled crane, it is noted huge cracks on the boom. Boom is consisted of five segments, where at three of them is identified critical cracks and it was decided to carry out reparation of segments by welding. In this paper, in addition to reparation of boom, it is presented technology of reparation by welding.

Figure 1 Crack of telescopic arm of vehicle-mounted crane

2 ANALISYS OF PRESENT CONDITIONS OF CARIN'S BOOM

In order to determine the condition of damaged steel construction of boom, it is executed a preliminary visual inspection, and testing of welded joints and base material boom's segments. Preliminary visual inspection of the damaged segments indicated the presence of a large number of defects (discontinuities), cracks, fractures and deformities of the outer and inner surface of the steel structure segments in weld joints and base material. Some of them are shown in figures (Figure 1, Figure 2).

Figure 2 Deformation and cracks on steel construction of vehicle-mounted crane

3 REPARATION ACTIVITIES

From the results of tests it was decided to carry out repairs to the observed cracks in welded joints and in the base material and the replacement of few sheets on segments, which were damaged during the exploitation. It was planned to install the reinforcement in some areas.

It was made technical documentation for executing reparation of crane's boom. During the reparation it tends to maximize application of procedures, such as cutting, grooving and welding, to minimize the influence of additional stresses, which are inevitable in process of reparation [6]. When performing welding operations from the standpoint of ensuring the required

quality it should be strictly observe the regulations of this technology, which is made by Serbian (SRPS), European (EN) and International ISO standards in the field of welding.

Due to amount and complexity of the works in reparation of crane's boom, it was made following of the preparatory activities:

- Disassembling of boom onto separate segments
- Cleaning the surface of segments from coatings applying the process of sandblasting
- Transport of segments in a covered area and placing them of trays in a position to carry out the planned work
- Provision of equipment for gas cutting, grinding and welding
- Provision of equipment for gas preheating and reheating of welded joints and the contact temperature measurement
- Provision of fireproof material for covering weld joints and parts after welding of steel structures
- Establishing a team of engineers, specialized welders and support staff to perform the tasks of cutting, grinding and heating of materials and weld joints.

Table 1: Chemical composition of base material, %

Steel	Chemical composition, %												
SRPS EN 10027-1	C	Mn	Si	P	S	Cr	$Al_{min.}$	Mo	Nb	Ni	Ti	V	B
S690QL	0.20	1.7	0.80	0.025	0.015	1.50	0.018	0.70	0.06	2.00	0.12	0.12	0.80

4. PROPERTIES OF BASE MATERIAL

Table 1 gives the chemical composition of the base material, which is sheet, δ=7 mm thickness, made of low alloyed steel 690QL (SRPS EN 10027-1). Construction of crane's boom is assembled of this sheet plates. In Table 2 mechanical properties of the base material are given.

Table 2: Mechanical properties of base material

$R_{eh\ min.}$ N/mm^2	$R_{m\ min.}$ N/mm^2	$A_{min.}$ %
668	713	21.8
651	715	22.9

5. WELDABILITY

Steel S 690QL belongs low alloyed steel (C<0.20%) which have good weldability. Preheating is performed in general case where the temperature of environment is below +5 ^{0}C, while the welding at temperatures below -5 ^{0}C is prohibited with no special measures [7]. In the case of boom structures it is expected high stress conditions due to welding, preheating and slow cooling is required. After welding, heat treatment is not necessary to remove residual stresses.

6. WELDING PROCEDURES

Due to quality and dimensions of the base material, available equipment and the geometric complexity of the construction of boom, it is applied the MAG procedure, welding in the atmosphere of a mixture of gases Ar and CO_2 (M 21 by EN 14 175). It was obligatory for welding machines to be tested and in terms of safety and in terms of maintaining required welding parameters. Electrical characteristics should be reliably maintained and, if necessary, changed, with ability for their reading and control.

7. FILLER MATERIAL

Due to quality and dimensions of the base material, complexity of construction and welding position, it is determined following filler materials for the MAG procedure: welding wire in a mixture of Ar and CO_2 gases M 21 (according to EN 439), Mn3Ni1CrMo (according to EN 12 534), ER 100 S - 1 (according to AWS-5.28), with commercial sign MIG 75 (Jesenice), Ø1.2 mm in diameter. Tables 3 and 4 give the chemical composition and mechanical properties of filler material.

Table 3: Chemical composition of filler material, %

C	Si	Mn	Cr	Ni	Mo
0.08	0.60	1.70	0.25	1.50	0.50

Table 4: Mechanical properties of filler material

$R_{p0.2}$ N/mm^2	Rm N/mm^2	A_5 %	A_V, -40 ^{0}C J
> 690	770 - 940	> 17	> 47

8. REVIEW AND SELECTION OF CHARACTERISTIC JOINTS

Default quality level of weld joints (SRPS C.T3.010) for corner joints applied in the reparation is D, which implies visual inspection of 100% and penetrant control of 10% after welding, while the butt joints which are placed to carry out reinforcements require quality level of B, which means the visual and penetrant control of 100%. The choice of weld type (groove type) was performed on the basis of the SRPS C.T3.030 standard and shown in the lists of welding technologies.

9. WELDING PARAMETERS USED IN REPARATION

Used parameters of MAG (135) welding process:
- Type of welding current: DC (=)
- The strength of welding current: 150 - 240 A
- Arc voltage: 20 - 27 V
- Gas flow: 10 - 14 l / min.
- Polarity: (+)

10. THE ACTUAL PRESENTATION OF CHARACTERISTIC JOINTS

10.1 Preparation of the groove

Before beginning of reparation it was done dismantling of boom onto five segments which were then placed in the bracket at horizontal position. Then it was performed cleaning procedure for all segments by sandblasting, to remove paint and prepare surface of base metal and welded joints for non-destructive testing (NDT). Welding surface (grooves) is formed by mechanical procedures (turning, grinding). The quality of prepared surfaces and tolerances of parts has been regulated by documentation of construction and technology in accordance with the SRPS C.T3.023 and SRPS C.T3.025 standards. Observed and marked cracks in welded joints and cracks in the base metal of segments are completely removed by grinding. In addition, wherever possible, tips of crack at the sheet plane (base material) were rounded by drill and irregularities (notches, sharp edges) were removed by grinding till metallic shine is achieved. Also, edges and roots of grooves are slightly rounded. All surfaces were cleaned of corrosion at the minimal width of 30 mm from the edge of the grooves with the metal wire brush till metallic shine is achieved. Greasy surfaces were cleaned by concentrated alcohol, trichloroethylene, at the minimal width of 50 mm from the edge of the groove. The time of preparation of the groove before welding should be as short as possible to reduce the possibility of subsequent contamination to a minimum. Figure 3 shows the preparation segments before reparation.

Figure 3: Segments preparation for auto crane repair

11. WELDING OF SEGMENTS OF BOOM CRANES

11.1 Reinforcement of segment No.1

Connection of the sheet of segment No. 1 with the new sheet 1200 x 800 mm, and segment No. 3 with the new sheet 1200 x 500 mm are shown in the welding plan of reinforcements at segments I, II and III of the 95t crane (Figure 4), performed as a corner and butt joint. Before welding the sheet was preheated to approximately 150 0C and between two passes temperature was maintained in the range 210-220 0C, while the sheet was fastened to the plate by tacks 5-10 mm big at a distance of 150-200 mm from each other. After the welding was done, it was performed slow cooling to reduce stresses and the possibility of defects in welded joints. Tack welds are carried out under the same conditions as the root welds and it is required to be melted down or grinded. This requirement applies to all weld joints where the tack welds are present.

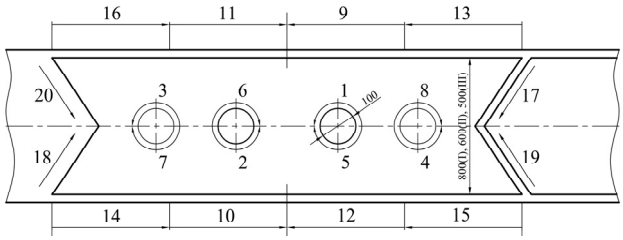

Figure 4: Welding plan of reinforcements in segments I, II and III (the numbers indicate the order of weld joints performing)

11.2 Reinforcement of segment No. 2 and its lamella continuation

Connection of the sheet of segment No. 2 with a new sheet with dimensions 1200 x 600 mm was carried out with the same parameters as the reinforcement of segment No. 1. Welding of these joints was performed with one or six passes from the medium to the ends with the weld length of 100-150 mm. The temperature between two passes was in the range of 210-220 0C. Continuation of the lamella of segment No. 2 is shown at the welding plan of vertical sheets for lamella of segment II (Figure 5) and is performed as a butt joint.

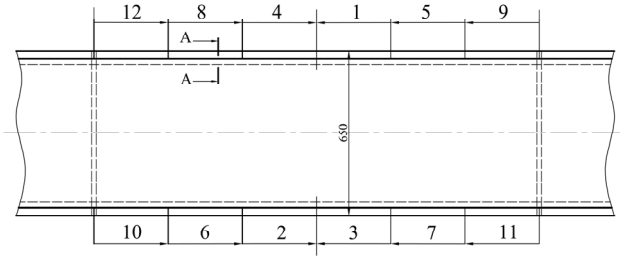

Figure 5: Welding plan of vertical sheets for lamella of segment II

11.3 Reparation of the vehicle-mounted crane stabilizers

Before welding of the stabilizer it was performed preheating at approximately 120 0C and temperature between two passes was maintained in the range 200-210 0C. Tack weld joints were performed under the same conditions as the root welds and it was required for them to be melted down or grinded. This requirement applies to all weld joints where the tack welds are present.

12. MEASUREMENTS OF CONTROL

Control of reparation by welding of steel structures of vehicle-mounted crane's boom, with a final assessment of eligibility in exploitation conditions is applied in three stages:

12.1 Control prior to welding, which includes:

- Insight into the certificate of quality of basic, filler and auxiliary materials,
- Verification of geometry regarding to dimensions of elements of structure,
- Verification of geometry regarding to shape of grooves and joints,
- Verification of surface cleaning,
- Testing of devices and equipment for welding,
- Verification of the professional ability of welders,
- Verification of the professional skills of welders (EN 287-1)
- Checking the security measures regarding to safety at work,
- Verification of required welding technology for all characteristic welds and qualities of material (EN ISO 15614-1),
- Insight into documentation of authorization for contractor to carry out welding works (BS EN ISO 3834),

12.2 Control during welding, which includes:

- Verification of application of regulated elements of technology (welding parameters, method of welding, order of welding operations).

12.3 Control of weld joints that includes:

- Dimensional control of the whole structure and geometry control of weld joints - 100%
- Visual inspection of weld joints - 100%
- Magnetic or penetrant control of weld joints - 100% for quality level B and 10% for the quality level D (SRPS C.T3.010)
- Radiographic or ultrasonic control of weld joints - minimum 75% for the quality level B (SRPS C.T3.010/95)

Parameters of the control and level of acceptability of defects in weld joints are determined according to standards: C.T3.010 and LST EN ISO 5817.

Figure 6: Appearance of steel construction of auto crane after repair

13. CONCLUSION

During the reparation, it was tended to apply procedures that minimize the occurrence of residual stress and strain, which are inevitable phenomena of reparation. Using welding technology it was successfully completed reparation of steel construction of boom of vehicle-mounted crane TADAHO TL 200 II /K. After the reparation (Figure 6) it was performed control of welded joints (visual, penetrant, and radiographic examination), and then it was assembled five segments of the boom and put into operation.

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