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State Analysis of Components of the Damaged Structure and Integrity Evaluation of Braces at the Spreader A2Rs - B 5500.55 + BRs

ABSTRACT

Excavation, transport and spreading of barren soil and crude ore are being performed by a number of machines during the continuous production process at excavation sites, such as: bucket-wheel excavator, conveyor and spreader (so called ECS system). Failure of any machine in the technological chain leads to the failure of the whole system, and therefore it should be considered a structure with a serial connection.

In this paper the results of non-destructive tests performed at welded joints and parent material (visual testing, penetrant testing, ultrasonic testing, radiographic testing, hardness testing) on the basis of which the state analysis of components of the damaged structure, integrity evaluation of braces of the cutting and discharge boom and homogeneity of welded joints of newly formed structures of the spreader A2Rs - B 5500.55 + BRs at the excavation site 'Drmno' near Kostolac, Serbia were performed, are presented. Taking into account the fact that the user of the spreader does not own the design and technical documentation, all tests and researches presented in this paper were performed under the assumption that the lattice structures of both cutting and discharge boom were made of structural steels S355 and S235, in accordance with standard EN 10027-1.

Keywords: spreader, state analysis, non-destructive testing, lattice structure, integrity evaluation

1. INTRODUCTION

In order to perform the state analysis of components of the damaged steel structure of the spreader A2Rs - B 5500.55 + BRs [1], integrity evaluation of braces of the cutting and discharge boom and homogeneity of welded joints of newly formed structures it was necessary to carry out the following:

- Visual testing (VT) of vital components of the damaged steel structure,
- Non-destructive tests in order to complete the state analysis and integrity evaluation of the spreader brace at which the crack was detected on the surface of parent material, in the near proximity of the butt-welded joint, by visual testing,
- Visual testing (VT) of all braces,
- Penetrant testing (PT) in order to detect surface discontinuities. Linear defect was detected on the surface of parent material, in the near proximity of the butt-welded joint at one of the vital braces of the spreader,
- Ultrasonic testing (UT) of internal homogeneity of parent material and welded joint, in the zone of parent material where the surface crack was detected, in the near proximity of the welded joint at one of the vital braces of the spreader,
- Radiographic testing (RT) of parent material and welded joint at one of the vital braces of the spreader, in the zone of parent material where the surface crack was detected, in the near proximity of the welded joint,
- Hardness testing, performed in the zone of parent material at the brace of the spreader where the surface crack was detected.

1.1 Basic technical properties of the spreader A2Rs - B 5500.55 + BRs

Spreader A2Rs - B 5500.55 + BRs is a machine which consists of 2 segments, the cutting part with the haulage conveyor and the discharge boom. Both parts

of the spreader are equipped with their own moving devices (2 crawlers), capable of independent movement. The above mentioned spreader is the constituent part of the fourth ECS system. SRs excavator performs the uncovering of the coal, or in other words the excavation of the overburden which is being transported by belt coveyors to the spreader of excavated material.

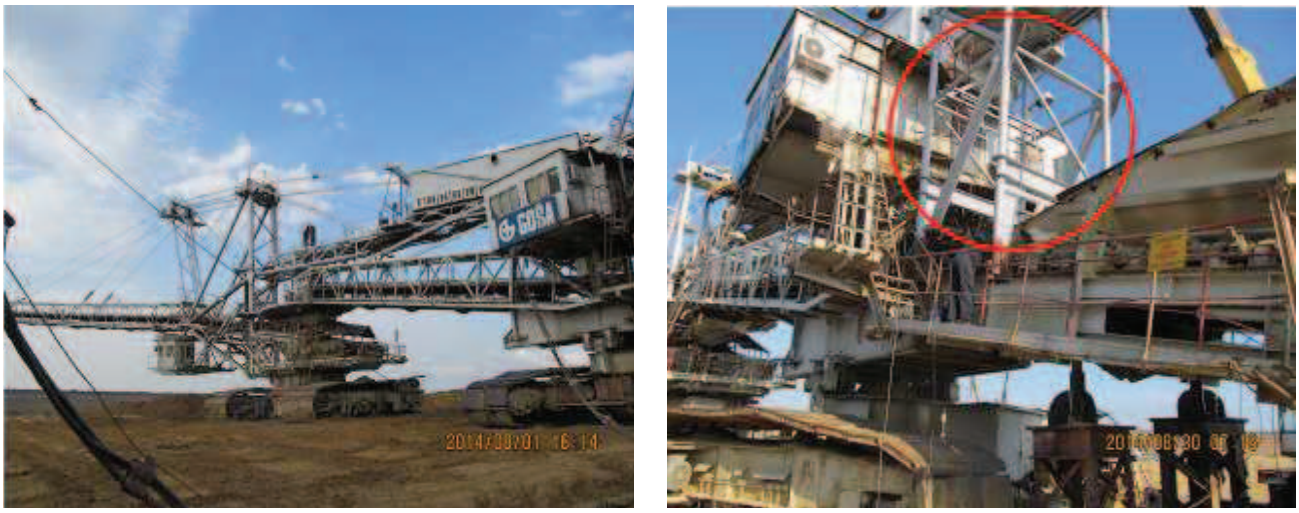
Basic technical properties of the spreader A2Rs - B 5500.55 + BRs [1] are as follows:

– maximum volume of the conveyor at the spreader: V = 5500,55 m^3/h,
– weight of the complete spreader: 1444 t,
– maximum length of material discharge: 110 m,
– maximum height of material discharge: 20 m,
– maximum velocity of the machine: 6 m/min.

Taking into account the fact that the user of the spreader does not own the design and technical documentation, all tests and researches presented in this paper were performed under the assumption that the lattice structures of both cutting and discharge boom were made of structural steels S355 and S235, in accordance with standard EN 10027-1 [2].

1.2 State Analysis of the Vital Steel Structure of the Spreader after the Breakdown

Spreader A2Rs - B 5500.55 + BRs before and after the breakdown is shown in *figure 1*. Breakdown of components of the vital lattice structure which occurred due to the uncontrollable sliding of the machine during the tempest which needed to be made from scratch is marked in *figure 1b* and shown in *figure 2*, while the state of braces in assembled condition is shown in *figure 3*. Some of the braces at which no damage was detected are shown in *figures 4a* and *4b*, while one of them at which the surface crack was detected on parent material, in the near proximity of the welded joint, is shown in *figure 4c*.



a) Appearance of the spreader before the breakdown b) Appearance of the spreader after the breakdown

Figure 1.- *Appearance of the spreader A2Rs - B 5500.55 + BRs before and after the breakdown*

a) Appearance of parts of the damaged vital steel structure b) Appearance of a part of the damaged vital steel structure

Figure 2.- *Appearance of parts of the vital steel structure which needed to be made from scratch*

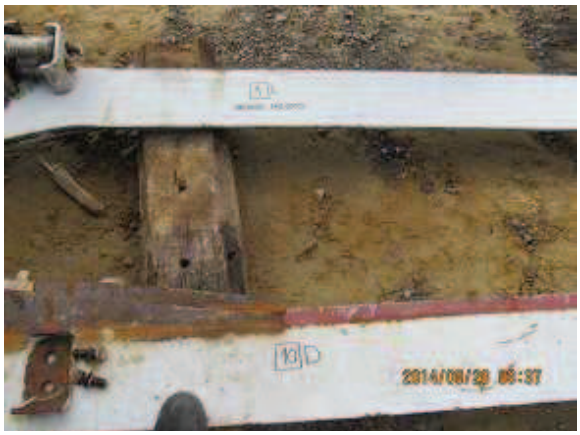
a) Appearance of the spreader before the breakdown

a) Appearance of the spreader after the breakdown

Figure 3.- *Appearance of the condition of vital braces of spreader A2Rs - B 5500.55 + BRs before and after the breakdown*

a) Undamaged braces

b) Undamaged braces



c) Right brace (10 D) with a surface crack

Figure 4.- *Appearance of the condition of a number of braces after the breakdown*

2. NON-DESTRUCTIVE TESTS NECESSARY FOR STATE ANALYSIS AND INTEGRITY EVALUATION OF THE BRACE AT WHICH THE SURFACE CRACK WAS DETECTED

In order to perform the state analysis and integrity evaluation of a brace of the discharge boom, shown in *figure 4c*, at which the surface crack was detected in parent material by visual testing, the following non-destructive tests were performed:

– Visual testing,
– Penetrant testing
– Ultrasonic testing
– Radiographic testing
– Hardness testing, performed on parent material.

2.1 Visual Testing Results

By visual testing [4] surface crack was detected at parent material of one of the braces of the discharge boom, in the near proximity of the butt-welded joint, which was confirmed by penetrant testing, *figure 4c*.

2.2 Penetrant Testing Results

Results of a penetrant test [5], performed at parent material of one of the braces of the discharge boom, in the near proximity of the butt-welded joint, which was also subjected to the test, are shown in *figure 5*. The crack was approximately 1 mm deep and was removed by fine grinding. Report nr. PT – 025/14 [6].

2.3 Ultrasonic Testing Results

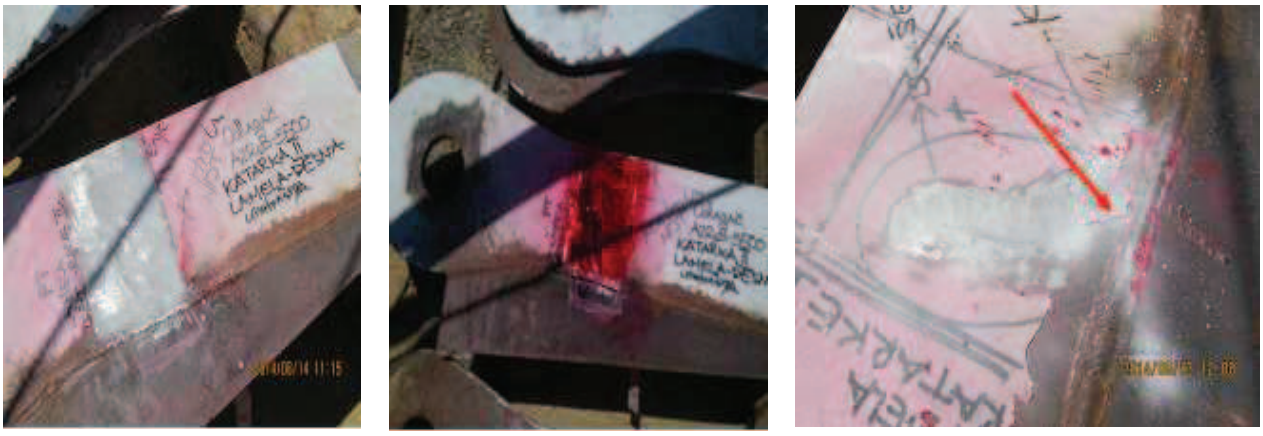
No internal homogeneities were detected in parent material and welded joints of braces by ultrasonic testing [7]. Report nr. UT – 042/14 [8].

2.4 Radiographic Testing Results

No internal homogeneities were detected in parent material and welded joints of braces by radiographic testing [9]. Report nr. RT – 044/14 [10].

2.5 Hardness Testing Results

Values in the range from 160 – 172 HB were determined at the parent material of braces by hardness



a) Discharge boom (mast II) b) Penetrant application c) Surface crack at parent material

Figure 5.- *Appearance of the process of penetrant testing*

testing [11]. On the basis of obtained results it could be concluded that no degradation (plastic deformation) of parent material occurred, because the braces are mostly being made of structural steel, grade S355. Report nr. HT – 011/14 [12].

3. INTEGRITY EVALUATION OF A SPREADER DISCHARGE BOOM BRACE AT WHICH THE SURFACE CRACK WAS DETECTED BY NON DESTRUCTIVE TESTING

Integrity of structures is a relatively new scientific and engineering discipline, which in a broader sense comprises state analysis and diagnostics of behaviour and relaxation, evaluation of service life and rehabilitation of structures which means that, apart from the usual situation in which it is necessary to assess the integrity of the structure when the flaw is detected by non-destructive testing, this discipline also comprises the analysis of the stress state of the structure.

On the basis of the analysis of results of performed tests it was determined that the integrity of a brace at which the surface crack was detected is not threatened, which could be said about the spreader as a whole after the installation of the new segment of steel structure, *figure 6*.

4. CONCLUSION

On the basis of qualitative analysis of the new segment of steel structure (*figure 6a*) and its successful installation (*figure 6b*), as well as taking into account the condition of all braces after the completion of the assembly of the cutting boom and discharge boom, the spreader has been restored into functional condition and put into service.

a) Appearance of the new segment of steel structure b) Spreader after the repair of steel structure and installation

Figure 6.- *Appearance of the spreader A2Rs - B 5500.55 + BRs after being repaired and put into service*

Acknowledgement

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