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Analiza stanja vitalne čelične konstrukcije kabine rukovaoca rotornog bagera nakon havarije i sanacije

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Na deponiji uglja termoelektrane "Nikola Tesla A" u Obrenovcu (Srbija), rade dva rotorna bagera interne oznake DU1 i DU2, koji su proizved francuske fabrike "Ameco" i kreću se po kružnoj stazi (tzv. polarna staza), uz napomenu da u Istočnoj Evropi rade samo tri bagera tog tipa. Treći rotorni bager istog proizvođača radi na deponiji uglja termoelektrane "Nikola Tesla B" u Obrenovcu. U radu je prikazana analiza stanja vitalne čelične konstrukcije kabine rukovaoca rotornog bagera DU 2, izrađene od cevi različitih prečnika i debljina lima, nakon havarije izazvane udarom kamena u poprečni nosač konstrukcije. Kamen se nalazio u otkopanom uglju jedne od kašika rotora bagera. Prilikom udara kamena poprečni nosač konstrukcije kabine rukovaoca se savio i popucali su zavareni spojevi između prirubnica na sredini poprečnog nosača i zavareni spojevi na mestima veze poprečnog nosača sa vertikalnim nosačima konstrukcije. S obzirom da korisnik bagera ne poseduje projektnu i tehničku dokumentaciju sanacija oštećenja sprovedena je pod predpostavkom da je rešetkasta konstrukcija kabine rukovaoca bagera izrađena od konstrukcijskih čelika, koji se uglavnom primenjuju za izradu rotornih bagera. Na osnovu analiza stanja nakon privremene sanacije oštećenja došlo se do zaključka da je za trajno obezbeđenje integriteta noseće čelične konstrukcije kabine rukovaoca rotornog bagera du2 kao celine potrebno izvršiti zamenu oštećenog poprečnog noseća čelične konstrukcije.

Ključne reči: Rotorni bager, deponija uglja, zavarena konstrukcija, oštećenje, sanacija

1. UVOD

Na deponiji uglja termoelektrane "Nikola Tesla A" u Obrenovcu (in Serbian), rade dva rotorna bagera interne oznake DU1 i DU2, koji su proizved francuske fabrike "Ameco" [1] i kreću se po kružnoj stazi (tzv. polarna staza), uz napomenu da u Istočnoj Evropi rade samo tri bagera tog tipa. Treći rotorni bager istog proizvođača radi na deponiji uglja termoelektrane "Nikola Tesla B" u Obrenovcu.

U radu je prikazana analiza stanja vitalne čelične konstrukcije kabine rukovaoca rotornog bagera DU 2, izrađene od cevi različitih prečnika i debljina lima, nakon havarije izazvane udarom kamena u poprečni nosač konstrukcije. Kamen se nalazio u otkopanom uglju jedne od kašika rotora bagera. Prilikom udara kamena poprečni nosač konstrukcije kabine rukovaoca se savio i popucali su zavareni spojevi između prirubnica na sredini poprečnog nosača i zavareni spojevi na mestima veze poprečnog nosača sa vertikalnim nosačima konstrukcije.

Imajući u vidu dug period eksploatacije u teškim radnim uslovima (dinamička opterećenja sa promenljivim amplitudama) i posebno činjenicu da u vreme njihovog projektovanja praktično nisu postojale mogućnosti detaljne stress – strain analysis, najopterećeniji elementi i njihove veze moraju se proveravati discretely or continuously [2-10]. Ovo se posebno odnosi na zavarene spojeve i zavarene konstrukcije [3,5,8,9].

S obzirom da korisnik bagera ne poseduje projektnu i tehničku dokumentaciju sanacija oštećenja sprovedena je pod predpostavkom da je rešetkasta konstrukcija kabine rukovaoca bagera izrađena od konstrukcijskih čelika, koji se uglavnom primenjuju za izradu rotornih bagera [11].

a) Prikaz kompletnog rotornog bagera *b) Prikaz rotornog bagera u radu*

Slika 1. Prikaz rotornog bagera DU2 na deponiji uglja

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a) Prikaz rotora i kabine rukovaoca bagera *b) Desna strana konstrukcije* *c) Leva strana konstrukcije*

Slika 2. Prikaz rotora i vitalnih delova konstrukcije kabine rukovaoca bagera

a) Desna strana konstrukcije, savijanje nosača i otkaz ZS *b) Savijanje poprečnog nosača i oštećenja ZS na prirubnici i vertikalnom stubu* *c) Leva strana konstrukcije, savijanje nosača i otkazi ZS*

Slika 3. Oštećenja na poprečnom nosaču konstrukcije izazvana udarom kamena koji se nalazio u otkopanom uglju jedne od kašika rotora bagera

Na sl. 1 prikazan je rotorni bager DU2 na deponiji uglja, na sl. 2 rotor i vitalni delovi konstrukcije kabine rukovaoca bagera i na sl. 3 oštećenja na poprečnom nosaću konstrukcije izazvana udarom kamena koji se nalazio u otkopanom uglju jedne od kašika rotora bagera.

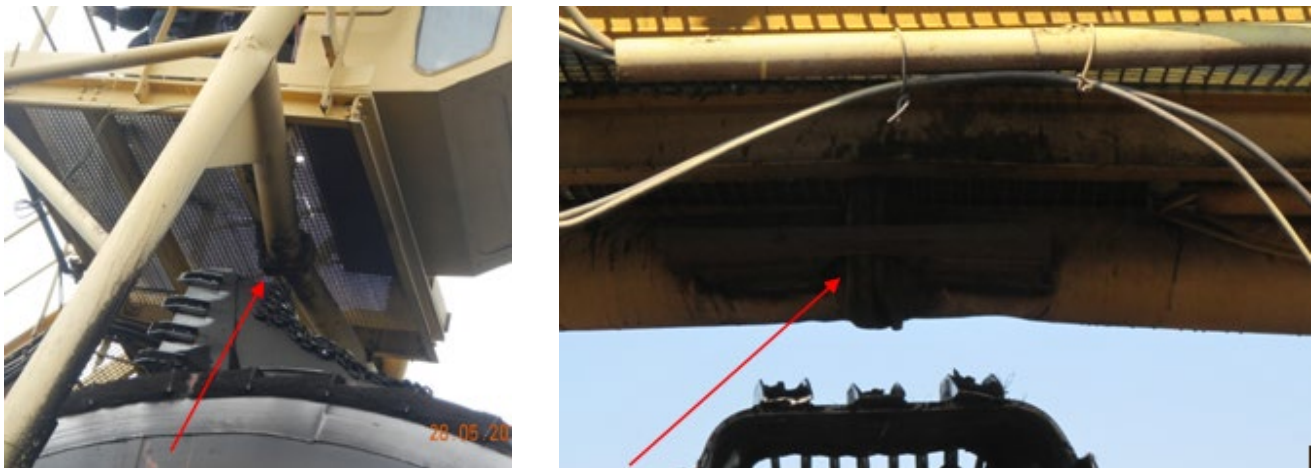
2. SANACIJA OŠTEĆENE VITALNE KONSTRUKCIJE KABINE RUKOVAOCA BAGERA

Da bi se u potpunosti obezbedilo integritet noseće čelične konstrukcije kabine rukovaoca rotornog bagera DU2, u višegodišnjem poriodu, potrebno je izvršiti zamenu oštećenog poprečnog noseće čelične konstrukcije kabine rukovaoca bagera.

Sva zavarivanja za privremenu i trajnu sanaciju noseće čelične konstrukcije kabine rukovaoca rotornog bagera DU2 na deponiji uglja termoelektrane **"**Nikola Tesla A**"** u Obrenovcu treba uraditi sučeonim i/ili ugaonim zavarenim spojevima cevi i zavarenim spojevima cevi sa prirubnica od lima, prema propisanoj tehnologiji [11].

3. STANJE POPREČNOG NOSAĆA ČELIČNE KONSTRUKCIJE KABINE RUKOVAOCA ROTORNOG BAGERA DU2 NAKON PRIVREMENE SANACIJE

Stanje poprečnog nosaća vitalne čelične konstrukcije kabine rukovaoca rotornog bagera DU2 nakon privremene sanacije, izvršene prema tehnologije zavarivanja [12], prikazano je na sl. 4 - sl. 6.



a) Oštećenje poprečnog stuba pre sanacije *b) Sanacija ZS na prirubnicama poprečnog stuba*

Slika 4. Prikaz sanacije središnjeeg dela poprečnog nosača kabine rukovaoca bagera

a) Desna strana konstrukcije, savijanje nosača i otkazi ZS

b) Sanirani ZS poprečnog i vertikalnog nosača stuba (pogled sa boka)

c) Sanirani ZS poprečnog i vertikalnog nosačeg stuba (pogled odozgo)

Slika 5. Prikaz sanacije ZS između poprečnog i vertikalnog nosačeg stuba kabine rukovaoca rotornog bagera (desna strana)

a) Leva strana konstrukcije, savijanje nosača i otkazi ZS

b) Sanirani ZS poprečnog i vertikalnog nosačeg stuba (pogled bočno)

c) Sanirani ZS poprečnog i vertikalnog nosećeg stuba (pogled odozgo)

Slika 6. Prikaz sanacije ZS između poprečnog i vertikalnog nosačeg stuba kabine rukovaoca rotornog bagera (leva strana)

3. ZAKLJUČAK

Da bi se u potpunosti obezbedilo integritet vitalne čelične konstrukcije kabine rukovaoca rotornog bagera oznake DU2 na deponiji uglja termoelektrane **"**Nikola Tesla A**"** u Obrenovcu kao celine u višegodišnjem poriodu, potrebno je izvršiti zamenu oštećenog poprečnog preseka noseće čelične konstrukcije kabine rukovaoca bagera.

Sva zavarivanja za sanaciju vitalne čelične konstrukcije kabine rukovaoca rotornog bagera oznake DU2 na deponiji uglja termoelektrane **"**Nikola Tesla A**"** u Obrenovcu treba uraditi sučeonim i/ili ugaonim zavarenim spojevima cevi i zavarenim spojevima cevi sa prirubnica od lima prema propisanoj tehnologiji zavarivanja [11], uz napomenu da je zato što korisnik opreme ne poseduje projektnu i tehničku dokumentaciju tehnologija međusobnog zavarivanja cevi i zavarivanja cevi sa prirubnicama definisana za konstrukcijske čelike, koji se uglavnom primenjuju za izradu konstrukcija rotornih bagera.

Opšti zaključak je da rotororni bager DU2 u narednom periodu, do trajne sanacije noseće čelične konstrukcije kabine rukovaoca bagera, može da radi uz redovna jednonedeljna vizuelna ispitivanja delova konstrukcija na kojima je urađena sanacija i ostalih vitalnih konstrukcija bagera pri čemu obavezno treba voditi knjigu zapažanja.

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State Analysis of the Vital Steel Structure of the Bucket-wheel Reclaimer Operators Cabin After the Breakdown and the Rehabilitation

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There are 2 bucket –wheel reclaimers, internally labelled as DU1 and DU2, made by french manufacturer 'Ameco', that operate at the open pit surface mine which belongs to the thermal power plant 'Nikola Tesla A' in Obrenovac. They are moving along the polar path and it should be noted that there are only 3 reclaimers of that kind in Eastern Europe. The third bucket-wheel reclaimer, made by the same manufacturer, operates at the open pit surface mine that belongs to the thermal power plant 'Nikola Tesla B' in Obrenovac. In this paper the state analysis of the vital steel structure of the bucket-wheel reclaimer DU2 operators' cabin, made of pipes of various diameters and thicknesses, after the breakdown caused by a rock that hit the horizontal support of the structure is presented. The rock was located in the excavated coal within a bucket of the bucket-wheel reclaimer. The horizontal support of the operators' cabin structure has bent and welded joints between flanges at the middle of the horizontal support, as well as welded joints at bonds of the horizontal support with vertical supports of the structure, have cracked due to the impact of the rock. Taking into account the fact that the user of the bucket-wheel reclaimer does not own the design and technical documentation, damage repair was carried out under the assumption that the lattice structure of the operators' cabin was made of structural steels, which are mostly being used for the manufacture of bucket-wheel reclaimers. On the basis of state analysis after the temporary repair of damages the conclusion arose that for the permanent provision of integrity of the support steel structure of the bucket-wheel reclaimer DU-2 operators' cabin as a whole it is necessary to replace the damaged horizontal support.

Keywords: Bucket-wheel reclaimer, open pit surface mine, welded structure, damage, repair

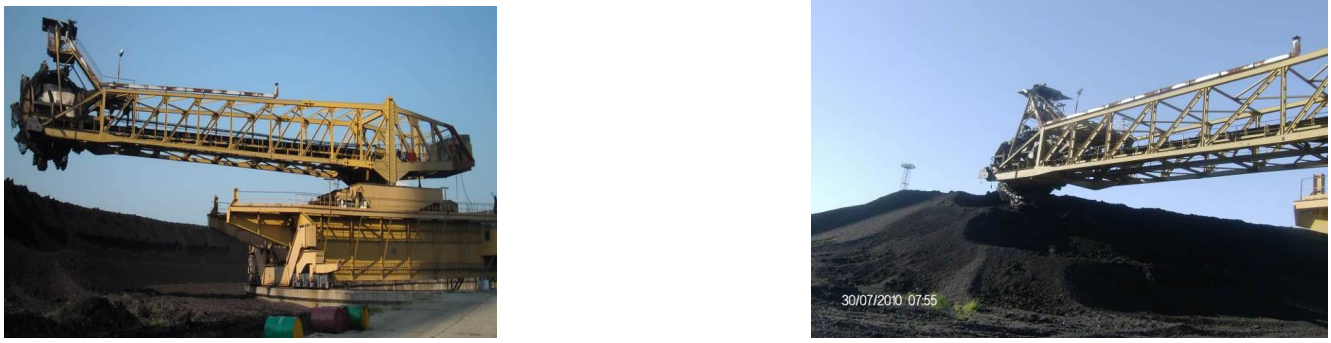
1. INTRODUCTION

There are 2 bucket–wheel reclaimers, internally labelled as DU1 and DU2, made by french manufacturer 'Ameco' [1], that operate at the open pit surface mine which belongs to the thermal power plant 'Nikola Tesla A' in Obrenovac. They are moving along the polar path and it should be noted that there are only 3 reclaimers of that kind in Eastern Europe. The third bucket-wheel reclaimer, made by the same manufacturer, operates at the open pit surface mine that belongs to the thermal power plant 'Nikola Tesla B' in Obrenovac.

In this paper the state analysis of the vital steel structure of the bucket-wheel reclaimer DU2 operators' cabin, made of pipes of various diameters and thicknesses, after the breakdown caused by a rock that hit the horizontal support of the structure is presented. The rock was located in the excavated coal within a bucket of the bucket-wheel reclaimer. The horizontal support of the operators' cabin structure has bent and welded joints between flanges at the middle of the horizontal support, as well as welded joints at bonds of the horizontal support with vertical supports of the structure, have cracked due to the impact of the rock.

Taking into account the long period of exploitation under hard operating conditions (dynamic loads with changeable amplitudes), and especially the fact that, during the period when they were designed, there were practically no possibilities of detailed stress-strain analysis, the most loaded elements and their bonds had to be inspected discretely or continuously [2-10]. This especially refers to welded joints and welded structures [3, 5, 8, 9].

It should be noted that the user of the bucket-wheel reclaimer does not own the design and technical documentation. Therefore damage repair was carried out under the assumption that the lattice structure of the operators' cabin was made of structural steels, which are mostly being used for the manufacture of bucket-wheel reclaimers [11].



a) Appearance of the bucket-wheel reclaimer *b) Appearance of the bucket-wheel reclaimer in operation*

Figure 1: Appearance of the bucket-wheel reclaimer DU2 at the open pit surface mine

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a) Appearance of the bucket-wheel and of the operators' cabin

b) Right side of the structure

c) Left side of the structure

Figure 2: Appearance of the bucket-wheel and vital parts of the operators' cabin structure

a) Right side of the structure, bent support and damaged welded joints

b) Bent horizontal support and damaged welded joints at the flange and vertical beam

c) Right side of the structure, bent support and damaged welded joints

Figure 3: Damages at the horizontal support of the structure caused by the impact of the rock located in the excavated coal at one of the buckets

In figure 1 the bucket-wheel reclaimer DU2 at the open pit surface mine is shown, while in figure 2 the bucket-wheel and vital parts of the operators' cabin are presented. In figure 3 the damages at the horizontal support caused by the impact of the rock located in the excavated coal at one of the buckets are presented.

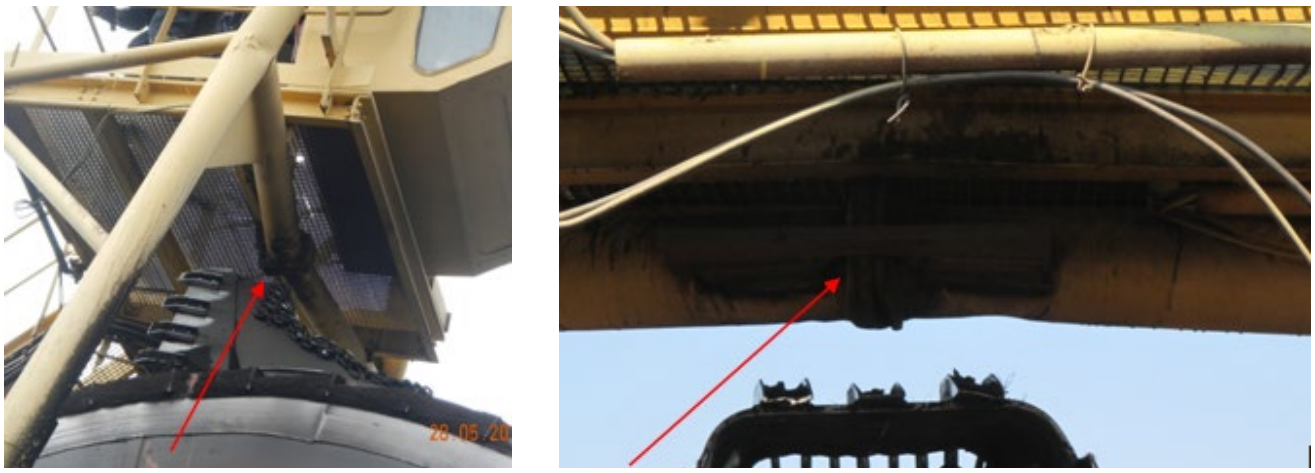
2. REPAIR OF THE DAMAGED VITAL STRUCTURE OF THE OPERATORS'

In order to fully ensure the integrity of the support steel structure of the bucket-wheel reclaimer DU2 operators' cabin as a whole during a long period of time, it is necessary to replace the damaged horizontal support of the operators' cabin steel structure.

All welding works for the temporary and permanent repair of the support steel structure of the operators' cabin should be performed in accordance with the prescribed welding technology [11].

3. CONDITION OF THE HORIZONTAL SUPPORT OF THE OPERATORS' CABIN STEEL STRUCTURE AFTER TEMPORARY REPAIR

Condition of the horizontal support of the vital steel structure of the bucket-wheel reclaimer DU2 operators' cabin after temporary repair, performed in accordance with the welding technology [11], is presented in figures 4-6.



a) Damage at the horizontal support before repair *b) Repair of welded joints at the flanges of the horizontal beam*

Figure 4: Appearance of repair of the middle section of the operators' cabin horizontal support

a) *Right side of the structure, bent support and damaged welded joints*

b) Repaired welded joint between the horizontal and vertical support (view from the side)

c) Repaired welded joint between the horizontal and vertical support (view from above)

Figure 5: Appearance of the repaired welded joint between the horizontal and vertical support of the operators' cabin (right side)

a) Left side of the structure, bent support and damaged welded joints

b) Repaired welded joint between the horizontal and vertical support (view from the side)

c) Repaired welded joint between the horizontal and vertical support (view from above)

Figure 6. Appearance of the repaired welded joint between the horizontal and vertical support of the operators' cabin (left side)

4. CONCLUSION

In order to fully ensure the integrity of the support steel structure of the bucket-wheel reclaimer DU2 operators' cabin as a whole during a long period of time, it is necessary to replace the damaged horizontal support of the operators' cabin steel structure.

All welding works for the temporary and permanent repair of the support steel structure of the operators' cabin should be performed in accordance with the prescribed welding technology [11]. It should be noted that the user of the bucket-wheel reclaimer does not own the design and technical documentation that refers to the technology of joining pipes, as well as joining pipes with flanges by means of welding for structural steels, which are mostly being used for the manufacture of bucket-wheel reclaimer structures.

The overall conclusion is that the bucket-wheel reclaimer DU2 could operate with regular one-week visual inspections of structural parts at which the repair was carried out, as well as other vital structures of the reclaimer, whereby it is obligatory to keep notes on these inspections.

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