Postupak reparacije guseničnog transportnog mehanizma samohodnog transportera BRs 1200

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U radu su prikazani i detaljno opisani specifični postupci koji se sprovode prilikom reparacije guseničnog transportnog mehanizma samohodnog transportera BRs 1200.29/32, čije izvođenje predstavlja osnovu za kvalitetno i efikasno održavanje ovih mašina na samom radilištu, kao i u remontnim radionicama. Ovi postupci predstavljaju kompleksne zahvate koji se obavljaju u okviru procesa preventivnog održavanja. Merilo uspeha procesa održavanja jesu radni proces sa što manje otkaza, zastoja, proces bez havarija, i u slučaju njihove pojave, mogućnost što bržeg otklanjanja, a to znači zadovoljstvo i korisnika i održavalaca.

Ključne reči: Preventivno održavanje, Samohodni transporter, Reparacija, Montaža/demontaža, Gusenični transport

1. UVOD

Površinska eksploatacija podrazumeva iskopavanje eksploatisanog materijala uz prethodno uklanjanje pokrivnog sloja i omogućuje eksploataciono iskorišćenje od preko 90% nalazišta. Ekonomska isplativost površinske eksploatacije određena je debljinom i geološkim karakterom pokrivnog sloja. Veliki površinski kopovi mogu da pokrivaju površinu od više stotina kvadratnih kilometara gde se za eksploataciju koristi teška mehanizacija uključujući: bagere kašikare, bagere dreglajne, moćne utovarivače, velike kamione – dampere, rotorne bagere, bagere vedričare, odlagače, samohodne transportere i trakaste transportere. [1]

Održavanje tehničkih sistema podrazumeva sprovođenje svih mera nužnih da bi jedna mašina, postrojenje ili cela fabrika funkcionisali na propisan način, razvijajući performanse u propisanim granicama, tj. sa traženim učincima i kvalitetom, bez otkaza. [2]

Održavanje tehničkih sistema u pogledu dinamike i sadržaja sprovođenja mora biti vrlo pažljivo odmereno i strogo usklađeno sa stvarnim potrebama. U suprotnom umesto visoke pouzdanosti, gotovosti, i efikasnosti, nepažljivo i prečesto sprovođenje, naročito složenih i dugotrajnih postupaka održavanja, može izazvati pojavu drugih, dodatnih i još ozbiljnijih otkaza, čime se može značajno smanjiti pouzdanost i efektivnost, uz osetno povećanje troškova [3,4]

Osnovni zadatak održavanja mašina na površinskim ugljenokopima čine aktivnosti kojima se sprečava pojava kvarova na opremi za proizvodnju i otklanjanje istih u najkraćem roku. Preventivno održavanje ima dominantnu ulogu u blagovremenoj detekciji oslabljenih mesta, njihovom otklanjanju i obezbeđenju radne sposobnosti i raspoloživosti rudarskih mašina. Lakoća održavanja i udobnost upravljanja su pokazatelji koji utiču direktno na ljude koji su u stalnom, svakodnevnom kontaktu sa mašinom. Lakoća održavanja utiče na vraćanje mašine iz stanja u otkazu u stanje radne sposobnosti. [5]

Odvijanje remontnih aktivnosti u sklopu preventivnog održavanja na površinskim kopovima kolubarskog basena predviđeno je jednom u toku godine,

odnosno ređe ili učestalije po potrebi. Obim radova i dužina njihovog trajanja određeni su opštim tehničkim stanjem mašine pri čemu je za remont potrebno između 15 i 45 dana. Na osnovu opsežnog pregleda delova i sklopova, sa aspekta pouzdanosti i ispravnosti, planiraju se aktivnosti koje bi se preduzele na mašini tokom zastoja za remont. [6]

2. SAMOHODNI TRANSPORTER BRs 1200.29/32

Samohodni transporter tip BRs 1200.29/32 je rudarska mašina koja na površinskom kopu deluje uz rotorni bager ili bager vedričar i predstavlja mobilnu vezu između bagera i trakastog transportera. Ove mašine imaju ulogu da preuzmu iskopani materijal sa bagera i pretovare ga na transporter pri čemu su u mogućnosti da premoste razlike u rastojanju, visini i uglu između bagera i trakastog transportera, čime se odlaže potreba za čestim pomeranjima transportera, što za posledicu ima smanjenje vremena zastoja sistema. [6,7]

Samohodni transporter sastoji se iz nekoliko konstrukcijskih celina, tzv. grupa gradnje:

- Gusenični transportni mehanizam – sastoji se iz dva nosača gusenica (levi i desni) koji je postavljen na gusenični lanac čijim se pokretanjem vrši kretanje ove mašine.
- Donja gradnja – sastoji se iz noseće konstrukcije u koji su uležistene poluosovine na koje su postavljeni nosači gusenica.
- Gornja gradnja – sastoji se od tornja na koji je uležistena prijemna i odložna traka i kabina rukovaoca transporterom sa nosećom konstrukcijom koja je postavljena na kugličnu obrtnu stazu preko koje je u spoju sa donjom gradnjom.
- Prijemna strela – sastoji se od rešetkaste konstrukcije u koji su postavljene prijemni levak, transportne rolne i gumena traka. Služi za prijem iskopanog materijala sa bagera i prenos ka odložnoj streli.
- Odložna strela – služi za dalji prenos iskopanog materijala i utovar istog na tračni transporter.

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Izgled samohodnog transportera sa grupama gradnje prikazan je na slici 1.

Slika 1: Samohodni transporter BRs 1200.29/32 sa grupama gradnje (1. gusenični transportni mehanizam; 2. donja gradnja; 3. gornja gradnja sa tornjem i kabinom rukovaoca; 4. prijemna strela; 5. odložna strela) [7]

3. REPARACIJA GUSENIČNOG TRANSPORTNOG MEHANIZMA

Reparacija predstavlja tačno propisan redosled operacija koji treba dosledno sprovesti kod oštećenih i razorenih mašinskih delova ili konstrukcija u cilju vraćanja u prvobitno stanje i ponovnog sticanja radne sposobnosti, nakon čega se ovi delovi ponovo ugrađuju u mašinsku konstrukciju. Najvažniji značaj reparacije je ekonomski, u vidu smanjenja troškova, obzirom da se ovim postupkom izbegava proizvodnja novog dela koji bi zamenio oštećeni. [8]

Slično kao i u radu [9], na osnovu analiza stanja može se doći do zaključka koje postupke treba sprovesti prilikom reparacije samohodnog transportera BRs 1200.29/32, a čije izvođenje predstavlja osnovu za

kvalitetno i efikasno održavanje ovih mašina na samom radilištu, kao i u remontnim radionicama.

Neposredno pre početka remonta samohodnog transportera BRs 1200.29/32, korisnik uređaja analizira nedostatke i oštećenja, nakon čega donosi odluku o neophodnoj reparaciji oba nosača gusenica. Reparacijom na radilištu obuhvaćeni su elementni guseničnog lanca, dok se tela nosača gusenica koja su demontirana sa transportera šalju na radioničku reparaciju.

Gusenični transportni mehanizam samohodnog transportera sastoji se iz dva nosača gusenica postavljenih u uređaj za transport, koji se nalazi donjoj gradnji transportera pomoću koga se transporter oslanja o tlo. Šematski prikaz nosača gusenica sa pripadajućim delovima prikazan je na slici 2.

Slika 2: Šematski prikaz nosača gusenice: 1. reduktor pogona sa kočionim mehanizmom; 2. pogonski točak sa ozubljenim vencem; 3. zatezni točak sa zateznim mehanizmom; 4. mali balanser; 5. veliki balanser; 6. potporna rolina; 7. gusenični lanac; 8. elektromotor; 9. čelična konstrukcija nosača gusenice; 10. uležištenje nosača gusenica [7]

3.1. Demontaža guseničnog transportnog mehanizma

Reparacija guseničnog transportnog mehanizma obavlja se u specijalizovanoj radionici za mašinski remont bagerske opreme, gde se sa radilišta dopremaju oba nosača

gusenice bez gusenica (slika 3). Nakon grubog mašinskog pranja sklopa i otklanjanja grubih nečistoća obavlja se kompletna demontaža na podsklopove i elemente. [10]

Slika 3: Prikaz nosača gusenice sa svim elementima, pre demontaže [10]

Iz kućišta reduktora potrebno je izvaditi sva vratila sa zupčanicima, počev od ulaznog pa do izlaznog. Iz zateznog točka demontiraju se osovina i cilindri sa zateznih vretena. Posle demontaže sklopa velikog balansera sa tela nosača gusenice pristupa se demontaži osovina i točkova trkača iz tela malog balansera (dvotočkovna kolica).

a)

b)

Slika 4: Reparacija zateznog točka

a) Demontirani zatezni točak; b) Zatezni točak sa zateznim mehanizmom nakon obavljene reparacije [10]

Reparacija pogonskog točka - takođe je i u slučaju kliznih ležajeva pogonskog točka uočena pohabanost istih, zbog čega je bilo neophodno izraditi nove. Osim toga, na samom pogonskom točku obavljeno je ručno

3.2. Postupci reparacije elemenata guseničnog transportnog mehanizma

Po završetku kompletne demontaže svih sklopova i elemenata nosača gusenice pristupa se finom pranju i odmašćivanju svakog pojedinačnog dela. Nakon toga obavlja se defektaža koja obuhvata vizuelnu i dimenzionu kontrolu elemenata od strane službe tehničke kontrole i tehnologa za reparaciju koji je zadužen za vođenje radova reparacije guseničnog transportnog mehanizma.

Na osnovu izmerenih vrednosti kao i vizuelnog pregleda, tehnolog sagledava koje mere odstupaju od dozvoljene tolerancije i koji elementi imaju fizička oštećenja, te na osnovu toga određuje postupak i dalji tok reparacije elemenata i sklopova.

U konkretnom slučaju na nosaču gusenica izvršeni su sledeći radovi reparacije:

Reparacija potpornih rolni - detaljnom defektažom potpornih rolni uočena je pohabanost kliznih ležajeva. Pristupilo se izradi novih kliznih ležaja obzirom da je, usled pohabanosti zatečena mera izvan dozvoljene tolerancije.

Reparacija zateznog točka - nakon konstantovane pohabanosti kliznih ležajeva unutar zateznog točka pristupilo se izradi novih, obzirom da je i u ovom slučaju zatečena mera, kao posledica habanja, izvan dozvoljene tolerancije (slika 4).

brušenje ozubljenog venca kako bi se otklonilo nagnječenje zuba. Takođe je izvršeno navarivanje oštećene površine vučnih segmenata koji se nakon toga ručno bruse (slika 5).

a)

b)

Slika 5: Reparacija pogonskog točka

a) Pogonski točak gusenice pre reparačije; b) Repariran pogonski točak [10]

Reparacija malih i velikih balansera nosača gusenica - odstupanje mera od dozvoljene tolerancije na kliznim ležajevima uočeno je kod 4 točka trkača, na kliznim ležajevima centralnog otvora malih balansera i na kliznim ležajevima centralnog otvora velikih balansera. Takođe, uočeno je odstupanje mera na centralnim otvorima malih balansera za osovinicu točka trkača i odstupanje mera na osovini točka trkača. Svi klizni ležajevi koji odstupaju od mere menjaju se novim tako što se stari ležajevi uklanjaju, nakon čega tehničar za snimanje pristupa snimanju mera i izradi crteža. Na osnovu izrađene tehničke dokumentacije, koja se dostavlja odeljenju mašinske obrade, vrši se izrada novih kliznih ležajeva sa merama za osnovnu obradu. Mašinska obrada na osnovnu meru podrazumeva izradu kliznih ležajeva sa dodatkom unutrašnjeg prečnika od 2 do 3 mm u odnosu na konačnu meru. Mašinska obrada na konačnu meru otvora kliznih ležajeva obavlja se nakon utiskivanja istih u točkove trkače i balansere. Vizuelnom kontrolom vrši se provera stanja tela balansera, odnosno pojava prskotina i fizičkih deformacija. Ukoliko su uočene prskotine i fizičke deformacije, potrebno je izvršiti saniranje istih zavarivanjem pukotina i popravkom deformacija. Reparacija osovine koje odstupaju od dozvoljene tolerancije sastoji se iz mašinske obrade osovine na meru manju za oko 1 mm u prečniku radi dodavanja materijala navarivanjem, zatim navarivanja oštećene osovine, strugarske obrade navarene osovine na fabričke mere i kontrole osovine postupcima bez razaranja - ispitivanje metodom magnetnog fluksa i snimanje ultra-zvučnom metodom.

Slika 6: Veliki balanser nosača gusenice [10]

Reparacija čelične konstrukcije nosača gusenice - sve vizuelno uočene pukotine na čeličnoj konstrukciji nosača gusenice saniraju se tako što se oštećena mesta obrađuju aparatom za gasno rezanje ili brusilicom, a potom se vrši popunjavanje navarivanjem materijala (slika 7).

Slika 7: Reparacija čelične konstrukcije nosača gusenice [10]

Reparacija reduktora pogona gusenica - posle obavljene demontaže reduktora pristupa se njegovoj reparačiji. U konkretnom slučaju uočena su odstupanja mera na kliznom ležaju drugog stepena i kliznom ležaju izlaznog vratila, pa se pristupa izradi novih kliznih ležajeva na osnovnu meru, a potom, njihovim utiskivanjem u kućišta i obradi otvora kliznih ležaja na konačnu meru. Kontrolom radijalnog zazor ležaja I stepena uočeno je odstupanje u odnosu na dozvoljeni radijalni zazor tako da je potrebna zamena ležajeva novim. Takođe se vrši obavezna zamena gumene zaptivke na ulaznom vratilu reduktora i zamena zaptivke od filca na poklopcu izlaznog vratila. Po obavljenoj reparačiji elemenata reduktora pristupa se montaži reduktora tako što se vrši postavljanje svih stepena prenosa u donji deo kućišta, njihovom uzublivanju, nanošenju hermetika (masa za zaptivanje kućišta) na čelo donjeg dela kućišta, spuštanjem gornjeg dela i zatezanje zavrtnja na sastavima polutke kućišta.

Slika 8: Delimično sklopljen reparirani reduktor [10]

Reparacija elektromotora pogona gusenica - reparacija elektromotora pogona gusenica obavlja se u specijalizovanoj radionici za remont električnih mašina. U toku procesa reparacije vrši se ispitivanje saosnosti vratila elektromotora, kao i zamena namotaja ukoliko je potrebno. Potom se elektromotor uparuje sa reduktorom posle njegove reparacije, nakon čega se vrši njihovo ispitivanje u ispitnoj stanici za probu reduktora. Prilikom probnog rada u ispitnoj stanici na elektromotoru uparenom sa reduktorom obavljaju se ogled praznog hoda, ogled kratkog spoja, ogled opterećenja, ogled zagrevanja, kao i dijagnostika stanja izolacije (slika 9). Po uspešnom završetku svih testova u ispitnoj stanici za probu reduktora, elektromotor i reduktor su spremni za montažu na nosač gusenice.

Slika 9: Ispitivanje elektromotora [10]

3.3. Montaža elemenata guseničnog transportnog mehanizma

Nakon što se obavi reparacija svih podsklopova i elemenata nosača gusenica pristupa se njihovoj montaži koja obuhvata sledeće aktivnosti:

- montaža sklopa malih i velikih balansera uz eliminisanje aksijalnog hoda balansera dodavanjem odstojnih prstenova odgovarajuće debljine;
- montaža reduktora na oslonce uz montažu i uzublivanje pogonskog točka;
- montaža zateznog točka sa zateznim mehanizmom;
- postavljanje potpornih rolni na nosače.

Nakon završene montaže glavnih elemenata guseničnog transportnog mehanizma na konstrukciju nosača gusenice pristupa se montaži sekundarnih elemenata. Na kočionom mehanizmu vrši se zamena gumica i kočionih obloga. Pored toga, obavlja se razrada mehanizma za zatezanje papuča. Na hidrauličnoj instalaciji sistema za podmazivanje obavlja se zamena dotrajalih cevi i creva za mazanje.

Po završetku montaže svih elemenata na nosač gusenice i dovođenja istog u funkcionalno stanje, vrši se antikorozivna zaštita kompletnog nosača.

4. ZAKLJUČAK

Sprovođenje aktivnosti reparacije mašinskih delova i konstrukcija tokom procesa remontnog održavanja rudarskih mašina zahteva visoki stepen naučnog i stručnog znanja iz različitih oblasti, (poznavanje materijala, vrste oštećenja, proračun mašinskih delova i konstrukcija...). Iz tog razloga reparaciju ne može da radi jedan čovek, već je za to neophodan dobro organizovan tim kompetentnih i iskusnih izvršilaca. Čest je slučaj da se ovim postupkom mnoge havarije mogu otkloniti na licu mesta, često bez demontaže celog sklopa. U takvim slučajevima omogućuje je izbeći velike troškove zbog prekida proizvodnje i angažovanja velikih materijalnih i ljudskih resursa.

Opšti zaključak rada je da svi prikazani i opisani specifični postupci koji se sprovode prilikom remonta samohodnog transportera BRs 1200.29/32, predstavljaju osnovu za kvalitetno i efikasno održavanje ovih mašina na samom radilištu, kao i u remontnim radionicama.

Opravednost ovih postupaka može se pronaći baš u razlogu da redovan remont u rudarskoj eksploataciji ima ogroman značaj po pitanju pouzdanosti sistema, a osnova dugotrajnosti rada bez otkaza jeste pravovremeno uočavanje problema i pravilno održavanje u toku procesa eksploatacije. Kada je pouzdanost sistema veća, smanjuju se troškovi održavanja sa što manje zastoja i otkaza, takođe, smanjuje se i radna aktivnost čime je smanjen rizik od povreda radnika.

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Repair Procedure of Belt Wagon BRs 1200 Crawler Unit

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The paper presents and describes in detail the specific procedures that are carried out during the repair of the crawler unit on the belt wagon BRs 1200.29/32, whose performance is the basis for high quality and efficient maintenance of these machines on site, as well as in repair shops. These procedures are complex interventions performed as part of the preventive maintenance process. The success of the maintenance process is presented as a workflow with as few failures and downtime as possible, also as a process without accidents, and in case of their occurrence, the possibility of the fastest elimination, all of which result in the satisfaction of both users and maintainers.

Keywords: Preventive maintenance, Belt wagon, Repairing, Assembly/disassembly, Crawler unit

1. INTRODUCTION

Open pit mining implies excavation of exploited material with prior removal of the cover layer and enables exploitation utilization of over 90% of the deposit. The economic viability of the open pit mining is determined by the thickness and geological character of the cover layer. Large open pit mines can cover an area of hundreds of square kilometres where heavy machinery is used for exploitation, including: power shovels, dragline excavators, powerful loaders, large dump trucks, bucket wheel excavators, bucket chain excavators, spreaders, belt wagons and belt conveyors. [1]

The maintenance of technical systems implies the implementation of all measures which are necessary for a machine, plant or the whole factory to function in a defined way, developing performance within defined limits, i.e. with the required effects and quality, without failure. [2]

The maintenance of technical systems in terms of dynamics and implementation measures must be very carefully calculated and strictly aligned with the actual needs. Otherwise, instead of high reliability, readiness, and efficiency, careless and too frequent implementation, of complex and lengthy maintenance procedures in particular, can cause additional and even more serious failures, which can significantly reduce reliability and effectiveness, as well as result in significant increase in costs. [3, 4]

The basic task in the process of machines maintenance on the open pit coal mines consists of activities that prevent the occurrence of failures on the production equipment as well as their elimination as soon as possible. Preventive maintenance has a dominant role in the timely detection of weakened areas, their elimination and ensuring the working capacity and availability of mining machines. Ease of maintenance and ease of operation are indicators that directly affect personnel who are in constant, daily contact with the machine. Ease of maintenance affects the machine restoration from the failure state to the working condition state. [5]

The conduct of overhaul activities as part of the preventive maintenance at the open pit mines of the Kolubara basin is planned once a year or as needed, i.e. less or more frequently. The scope of work activities and

their duration are determined by the general technical condition of the machine, whereby repairs take between 15 and 45 days. Based on a comprehensive inspection of parts and assemblies, from the aspects of reliability and proper functioning, activities are planned that would be undertaken on the machine during the downtime for overhaul. [6]

2. BELT WAGON BRS 1200.29/32

The belt wagon, type BRs 1200.29/32 is a mining machine which operates in the open mine along with a bucket wheel excavator or bucket chain excavator and represents a mobile connection between the excavator and the belt conveyor. These machines have the role to receive excavated material from the excavator and to reload it on the conveyor while being able to bridge the differences in distance, height and angle between the excavator and the belt conveyor, thus delaying the need for frequent conveyor movements and resulting in reduced time of the system downtime. [6,7]

The belt wagon consists of several construction units, the so-called construction groups:

- Crawler unit - consists of two crawler frames (left and right) with crawler tracks mounted on them which set in motion this machine.
- Substructure - consists of a load-bearing steel structure with the crawler frames mounted on axles for crawler frame.
- Superstructure - consists of a tower with a receiving boom, a discharge boom and the driver cabin with load-bearing steel structure, which is placed on a slewing ball race and through which it is connected to the substructure.
- Receiving boom - consists of a lattice construction in which the receiving chute, transport rollers and rubber belt are placed. It is used for receiving excavated material from the excavator and transferring it on the discharge boom.
- Discharge boom - is used for further transfer of the excavated material and loading on a belt conveyor.

The appearance of a belt wagon with construction groups is shown in Figure 1.

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Figure 1: Belt wagon BRs 1200.29/32 with construction groups (1. crawler unit; 2. substructure; 3. superstructure with tower and driver's cabin; 4. receiving boom; 5. discharge boom) [7]

3. REPAIR OF CRAWLER UNIT

Repairing is a precisely defined sequence of operations that should be consistently performed on damaged and wrecked machine parts and steel structures in order to restore them to their original condition and regain their working capacity, after which these parts are re-installed on the machine. The significance of repairing is primarily economic, since this procedure avoids the production of a new part that would replace the damaged one. [8]

Similar to the paper [9], based on the analysis of the situation, it can be concluded which procedures should be carried out during the repair of the belt wagon BRs 1200.29/32, and whose performance is fundamental for

high quality and efficient maintenance of these machines on site, as well as in repair shops.

Prior the start of the overhaul of the belt wagon BRs 1200.29/32, the user of this machine analyses the defects and damages, after which he/she makes a decision about the necessary repair of both crawler frames. The on-site repair involves the crawler track elements, while the crawler frames that have been dismantled from the crawler unit are sent to the workshop for repairing.

The crawler unit of a belt wagon consists of two crawler frames placed in the transport device, which is located in the substructure of the belt wagon and by which this machine rests on the ground. A schematic representation of the crawler frame with the associated parts is shown in Figure 2.

Figure 2: Schematic representation of the crawler frame: 1. gear unit with braking mechanism/brakes; 2. drive wheel with toothed ring; 3. tumbler with tension device; 4. two-wheel bogie; 5. four-wheel bogie; 6. supporting wheel; 7. crawler track; 8. drive unit; 9. crawler frame steel structure; 10. crawler frame bearing [7]

3.1. Dismantling of the crawler assembly unit

The repair of the crawler unit parts is performed in a specialized workshop for mechanical overhaul of mine machinery equipment, where both crawler frames are delivered from the work site (Figure 3). After the rough

machine cleaning of the assembly and removal of coarse dirt, complete disassembly of subassemblies and elements is performed. [10]

Figure 3: Crawler frame with all the parts, before disassembly [10]

All the gears need to be removed out of the gearbox housing, starting with the input and ending with the output gear. The shaft and hydraulic cylinders are dismantled from the spindles. After dismantling the assembly of four-wheel bogie from the crawler frame, the dismantling of the axles and track wheels from the two-wheel bogie construction can be performed.

3.2. Procedures for the repair of crawler unit parts

Upon completion of disassembly of all assemblies and elements of the crawler frame, fine cleaning and degreasing of each item is started. After that, the diagnostics is performed, which includes visual and dimensional control of the items by the technical control service and the technologist for repair who is in charge of conducting the repair works of the crawler unit.

Based on the found dimensions as well as on the visual inspection, the technologist considers which dimensions deviate from the allowance and which elements have any damage, and on that basis determines the procedure and further course of repair of elements and assemblies.

In a specific case, the following repairs were performed on the crawler frame:

Repair of supporting wheels - detailed diagnostics of supporting wheels showed that the bushings are battered. New bushings were made, since the dimensions were found to be beyond the allowance due to wear and tear.

Repair of the tumbler - after the constant wear of the bushings inside the tumbler, new ones were made, considering that in this case, too, the found dimensions, were beyond the allowance as an aftereffect of wear (Figure 4).

a)

b)

Figure 4: Repair of tumbler

a) Disassembled tumbler; b) Tumbler with tension device after repair [10]

Repair of the drive wheel - also in the case of bushings of the drive wheel, their wear was noticed, due to which it was necessary to make new ones. In addition, manual grinding of the toothed ring was performed at the

drive wheel itself in order to eliminate the teeth crushing. Welding of the damaged surface of the cams was also performed, which were then manually sanded (Figure 5).

a)

b)

Figure 5: Repair of the drive wheel

a) Drive wheel before repair; b) Repaired drive wheel [10]

Repair of two-wheel and four-wheel bogies of crawler frame - deviation of dimensions from the allowance on bushings was observed in 4 track wheels, then on bushings of the central shaft hub of two-wheel bogies and on bushings of the central shaft hub of four-wheel bogies. Also, the deviation of the dimensions on the track wheel axle hub of the two-wheel bogies and the deviation of the dimensions on the track wheel axle were noticed. All bushings that deviate from the default dimensions are replaced with new ones, after which the technician takes the measurements and makes the drawings. Based on these technical drawings, which are submitted to the machining department, new bushings with dimensions for basic processing are made. Machining on the basic dimensions implies the production of bushings with the addition of an inner diameter of 2 to 3 mm in relation to the final dimension. Machining to the final dimensions of the bushing hubs is performed after pressing them into the track wheels and bogies. Through the visual control the condition of the bogie structure is checked, i.e. the appearance of cracks and deformations. If cracks and deformations are noticed, it is necessary to repair them by welding cracks and repairing deformations. Repair of shafts that deviate from the allowance consists of machining shafts to a size of about 1 mm smaller in diameter in order to add material by welding, then welding the damaged shaft, followed by machining the welded shaft to default dimensions as well as control by non-destructive testing - magnetic flux leakage and ultrasonic testing.

Figure 6: Four-wheel bogie on the crawler frame [10]

Repair of the crawler frame steel structure - all visually noticed cracks on the crawler frame steel structure are repaired by treating the damaged areas with an oxy acetylene cutting torch or angle grinder, and then filling by welding material (Figure 7).

Figure 7: Repair of crawler frame steel structure [10]

Repair of the crawler unit gearbox - after the dismantling of the gearbox, its repair is started. In this particular case, deviations of dimensions were noticed on the second stage bushing and the output shaft bushing, so the new bushings are made within the default dimension values (outer diameter), and then, by pressing them into the housings and processing the bushing hubs within the default dimensions. The control of the radial clearance of the bearing of the first degree showed a deviation in relation to the tolerable radial clearance, so it was necessary to replace the bearings with new ones. It was also required to replace the rubber seal on the input shaft slot of the gearbox and to replace the felt seal on the cover of the output shaft slot. After repairing the gearbox elements, the gearbox was assembled by installing all the gears in the lower part of the gearbox housing, followed by the gear pairing, subsequent applying sealant (sealant for the gearbox housing) on the contact surface of the lower part of the housing, closing the gearbox with the upper part and finally fixing the housing halves with screws.

Figure 8: Repaired gearbox partially assembled [10]

Repair of the crawler drive unit - repair of the crawler drive unit is performed in a specialized workshop for drive unit repairs. During the repair process, the shaft coaxially of the drive unit is tested, and the windings are replaced if it is necessary. The drive unit is then paired with the gear unit after its repair, after which they are tested in the gear unit test station. During the test operation in the test station the idling test, the short circuit test, the load test, the heating test, as well as the diagnostics of the insulation condition are performed (Figure 9). Upon successful completion of all tests in the gear unit test station, the drive unit and the gear unit are ready for mounting on the crawler frame.

Figure 9: Drive unit testing [10]

3.3. Assembly of the crawler unit parts

After the repair of all subassemblies and elements of the crawler frame is performed, their assembly is started, which includes the following activities:

- mounting of the two-wheel and four-wheel bogie assemblies along with elimination of the axial movement of the bogie by adding distance rings of the appropriate thickness;
- mounting the gear unit on supports along with mounting and pairing the drive wheel;
- installation of a tumbler with tension device;
- placing the supporting wheels on the supports.

After the assembly of the main elements of the crawler unit on the crawler frame construction, an assembly of the secondary elements is started. The rubber parts and brake pads of the brake mechanism are being replaced. In addition, the function of the crawler pad tensioning device is being restored. At the hydraulic installation of the lubrication system, worn-out pipes and lubrication hoses are replaced.

After the completion of the installation of all elements on the crawler frame and bringing it into a functional state, anti-corrosive protection of the complete frame is performed.

4. CONCLUSION

Machine parts and constructions repairing activities during the process of mining machines overhaul requires a high degree of scientific and professional knowledge from various fields (expertise in material types, types of damage, both machine parts and constructions calculations...). Consequently, repairing cannot be done by one person, but by a well-organized team of competent and experienced employees. It is a common case that this procedure can eliminate many accidents right on the spot, often without dismantling the entire assembly. In such cases, it is possible to avoid high costs due to the production cessation and the engagement of considerable material and human resources.

The general conclusion of the paper is that all the presented and described specific procedures that were carried out during the overhaul of the belt wagon BRs 1200.29/32, represent the basis for high quality and efficient maintenance of these machines right at the site, as well as in repair shops.

The justification of these procedures can be found in the fact that regular overhaul in mining industry is of great importance in terms of system reliability. In addition, the basis of long-term operation without failure is represented through timely detection of problems and proper maintenance during the exploitation process. When the reliability of the system is higher, maintenance costs are reduced with as few downtimes and cancellations as possible. Also, work activity is reduced, which decreases the risk of workers' injuries.

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