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MODERN TENDENCIES IN BTO SYSTEM DEVELOPMENT ON LIGNITE OPEN CAST MINES

SAVREMENE TENDENCIJE U RAZVOJU BTO SISTEMA NA POVRŠINSKIM KOPOVIMA LIGNITA

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Abstract *On our lignite open cast mines in operation is basic mechanization on the average more than twenty years old. Technical solutions applied on majority machines are old more than one decade, so as that are far away from high technical levels affected on modern world wide open cast mines. In this work are shown fundamental courses of classical basic mechanization development in the last two decades. Description according to each machine group is given as follows: excavators, stackers, and conveyors. The machines that are not a part of classical basic mechanization has not been handled out in this work, which implementation has been propagated for a long period of time but which are not standard equipment in lignite mines of higher capacities, as it is KSM machines, pipe conveyors, conveyors with horizontal bend, etc.*

Key words: *basic mechanization, BTO sistems, lignite open cast mine*

Apstrakt: *Na našim kopovima lignita u radu je osnovna mehanizacija prosečne starosti preko dvadeset godina. Primenjena tehnička rešenja na većini mašina su stara i po nekoliko decenija, tako da su daleko od najvišeg nivoa tehnike koja se primenjuje na modernim kopovima u svetu. U ovom radu su prikazani osnovni pravci razvoja klasične osnovne mehanizacije u poslednje dve decenije. Dat je prikaz po grupama mašina: bageri, odlagači i transporteri. U radu nisu obrađene mašine koje ne pripadaju klasičnoj osnovnoj mehanizaciji, a čije se uvođenje već duže vreme propagira kao mašine poput KSM-a, cevnih transportera, i transportera sa horizontalnim krivinama koji još uvek nisu standardna oprema u rudnicima lignita većeg kapaciteta.*

Ključne reči: *osnovna mehanizacija, BTO sistemi, kopovi lignita*

1. INTRODUCTION

Very big lignite reserves in our country and favorable basin locations from the aspect of energy and power transmission from the big consumptions, montan-geology and climate conditions, geometry of deposits and physically-mechanical characteristics of operating environment, offers possibilities for opening of big open cast mines with annual capacity to 20 10^6 tones of coal, allows introduction in exploitation big technological complexes of continued effect, respectively. Nearly on all open cast mines on spoil

1. UVOD

Velike rezerve lignita u našoj zemlji i povoljne lokacije basena sa aspekta prenosa energije i snage do velikih potrošača, rudarsko-geološki i klimatski uslovi, geometrije ležišta i fizičko-mehaničke karakteristike radne sredine, pružaju mogućnost za otvaranje velikih površinskih kopova sa godišnjim kapacitetima do 20 · 10^6 tona uglja godišnje, odnosno omogućavaju uvođenje u eksploataciju velikih tehnoloških kompleksa kontinuiranog dejstva. Na skoro svim površinskim kopovima kod nas na otkopavanju otkrivke (jalovine) i uglja u

(overburden) and coal removal in the use are highly product ional mechanization of continued effects. On mining, transportation and waste disposal are used technological complexes so-called BTO systems (bucket wheel excavators or bucket chain excavators – conveyors with rubber belt – console stackers), and on coal exploitation BTD or BTO systems (bucket wheel excavators or bucket chain excavators – conveyors with rubber belt – loading places or crusher plants).

Installing of this mechanization in operating is connected with opening of big lignite open cast mines. At the same time, with coal open cast mining system developing, the modernization of basic and accessory mechanization was done, adjusting the same to the operating conditions with all new experience and technology incorporated. On the other hand as a result of intense exploitation in the last few decades operating conditions on open cast mines are heavier and heavier because the better deposits are already mined. It is the case why we are every day faced with issues of separated beds or steep or deposit parts tectonically disturbed where without the use of modern mechanization we could not be able to achieve big production and economic effects.

Up to beginning of 1990s technical and technology used on our open cast mines followed modern world trends and achieved capacities and equipment output could be measured with achieved results in the most developed mining countries. Besides this, it was build very strong accompanying industry, dealing very successfully with the production of spare parts, accessory machines, rubber belts, and so on.

However, in the last few years because of different kind of reasons and before all of economy sanctions toward our country, it culminated with big backlogs in replacements of old and procurement of the new one mechanization, especially in the case of implementation up-to-date solutions.

2. BUCKET WHEEL EXCAVATORS OR BUCKET CHAIN EXCAVATORS

At present the rotor wheel excavator is for sure the widest spread machine on lignite open cast mine for mining of soft and middle solid materials. During more than one decade of developing the constructions of it were made that can satisfy very different mine-technical requests of output. This constructions allows high technically-economical indicators in the operations, thanks to, and before all, the ranges technically-exploitation advantage according to the other kind of excavators (very high safety in operation, relatively low metal implementation 0.2 — 1.1 t.h/m^3, low specific energy

primeni je visokoproduktivna mehanizacija kontinuiranog dejstva. Na otkopavanju, transportu i odlaganju jalovine koriste se tehnološki kompleski tzv. BTO sistemi (rotorni bageri ili vedričari – transporteri sa gumenom trakom – konzolni odlagači), a na eksploataciji uglja BTD ili BTU sistemi (rotorni bageri ili vedričari – transporteri sa gumenom trakom – utovarna mesta ili drobilična postrojenja).

Uvođenje ove mehanizacije u rad kod nas vezuje se za otvaranje prvih velikih površinskih kopova lignita. Uporedo sa razvojem sistema površinske eksploatacije ugljeva išlo je i usavršavanje osnovne i pomoćne mehanizacije koja se sve više prilagođava uslovima radne sredine i u koju se ugrađuju sva nova iskustva i tehnologije. Sa druge strane, kao posledica intenzivne eksploatacije poslednjih dekada, uslovi rada na površinskim kopovima sve su teži, jer su, po pravilu, bolji delovi ležišta već otkopani. Zbog toga se sve češće susrećemo sa problematikom otkopavanja raslojenih, strmih ili, pak, delova ležišta poremećenih tektonikom, gde se bez korišćenja savremene mehanizacije ne bi postigli veliki proizvodni i ekonomski efekti.

Do početka devedesetih godina primenjena tehnika i tehnologija na našim površinskim kopovima pratila je najsavremenije svetske tokove, a ostvareni kapaciteti i iskorišćenje opreme mogli su se meriti sa rezultatima ostvarenim u najrazvijenijim rudarskim zemljama. Osim ovoga, izgrađena je i veoma snažna prateća industrija koja se veoma uspešno bavila proizvodnjom rezervnih delova, nekih pomoćnih mašina, gumenih traka itd.

Međutim, poslednjih nekoliko godina zbog raznih uzroka, a to su, pre svega, ekonomske sankcije prema našoj zemlji, došlo je do velikog zastoja u zameni dotrajale i nabavci nove mehanizacije, tako da je izgubljen korak u poređenju sa razvijenim zemljama sveta, pre svega, kada se radi o primeni savremenih rešenja.

2. ROTORNI BAGERI I VEDRIČARI

Rotorni bager je danas, svakako, najrasprostranjenija mašina na površinskim kopovima lignita za otkopavanje mekih i srednje tvrdih materijala. Tokom višedecenijskog razvoja ovih mašina stvorene su konstrukcije koje mogu na zadovoljavajući način da odgovore veoma raznovrsnim rudarsko-tehničkim zahtevima otkopavanja. Ove konstrukcije obezbeđuju visoke tehničko-ekonomske pokazatelje u radu, zahvaljujući, pre svega, nizu tehničko-eksploatacionih prednosti u odnosu na druge vrste bagera (visoka sigurnost u radu, relativno mala

usage 0.15-0.5 kWh/m^3 and high coefficient of operating organ utility effect 0.8-0.9. Currently in appliance is huge number of bucket wheel chain classifications and according to the German classification the same excavators are divided in terms of basic designed characteristics in categories A, B and C.

ugradnja metala, 0.2-1.1 t.h/m^3, mala specifična potrošnja energije, 0.15-0.5 kWh/m^3 i visoki koeficijent korisnog dejstva radnog organa 0.8-0.9. Danas je u primeni veliki broj klasifikacija rotornih bagera, a prema nemačkoj klasifikaciji rotorni bageri se prema osnovnim konstruktivnim karakterisikama dele u klase A, B i C.

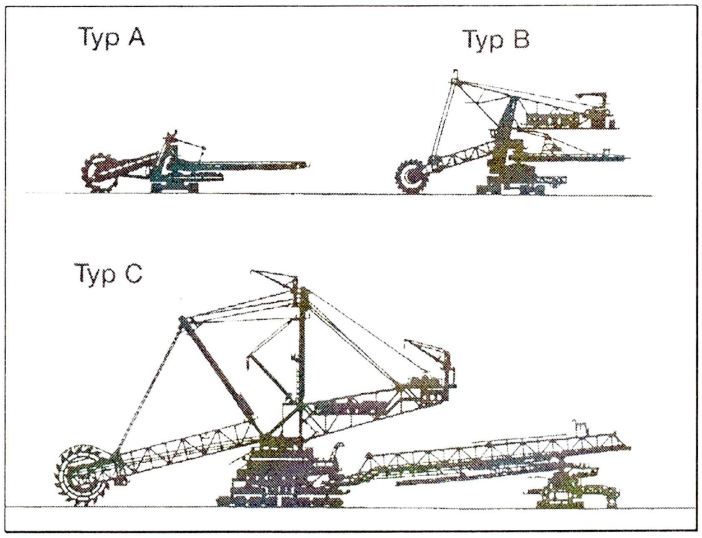


Table 1 Comparative parameters for different type of bucket chain excavator
Tabela 1 Uporedni parametri različitih tipova rotornih bagera

Excavator type	A	B	C
Capacity (m^3/h)	420-6000	3600-7500	7300-22700
Drive mass (t)	55-1200	1200-3500	6000-14000
Rotor wheel diameter (m)	4,2-12	8,4-12,5	17,3-21,6
Rotor wheel power (kW)	75-1000	750-1500	1500-5040
Rotor wheel torque (kNm)	75-2200	2000-7000	4500-12000

Increasing concentration of production on open cast mines required from machinery manufacturers: increasing of units capacities and mining height, decrease of operating masses, better accommodation for mines-geological, hydro geological and climate conditions, increasing reliability, better comfort for workers dealing with machine and at the same the decreasing of time spent on servicing it, and so on.

Rastuća koncentracija proizvodnje na površinskim kopovima zahtevala je od proizvođača rudarskih mašina: povećanje jediničnih kapaciteta i otkopnih visina mašina, smanjenje radnih masa, bolje prilagođavanje rudarsko-geološkim, hidro-geološkim i klimatskim uslovima, povećanje pouzdanosti, poboljšanje komfora ljudstva koje opslužuje mašinu pri istovremenom smanjenju vremena opsluživanja i dr.

Intensively types and excavator models development occurred during 1960s and 1970s. In that period was delivered huge number of excavators with clear tendencies toward optimization of basic technical characteristics (capacity, reaching high, excavator spread, surface pressure, increasing of cutting power). The biggest bucket wheel excavator was manufactured at that time (1978 year) for the needs of lignite open cast mine "Hanbach", where today operate 7 of those excavators. The basic parameters for this excavator are: theoretical capacity of 19120 m^{3}rm/h, the rotor boom length 70,5m, rotor wheel diameter

Intezivan razvoj tipova i modela bagera pripada periodu šezdesetih i sedamdesetih godina. U navedenom periodu isporučen je veliki broj bagera sa jasnim tendencijama ka optimizaciji osnovnih tehničkih karakteristika (kapacitet, dohvatna visina, raspon bagera, površinski pritisak na tlo, povećanje rezne sile ...). Tada je proizveden i najveći rotorni bager (1978. godine) za potrebe površinskog kopa lignita "Hanbach", gde je danas u radu 7 ovakvih bagera. Osnovni parametri ovog bagera su: teoretski kapacitet 19120 m^{3}rm/h, dužina rotorne strele 70,5 m, prečnik rotornog točka 21,5 m, broj vedrica 18 kom., zapremina vedrice 6,34 m^3, snaga

21,5 m, bucket number 18 pcs., bucket volume 6,34 m^3, rotor wheel drive power 3360 kW and excavator operating mass b 13265 t. It was sure that so large and powerful excavator would not be exceeded in the near future. On the contrary, the requirements of open cast mine exploitation are more and more aimed at relatively big capacity excavators, but mobile ones with low masses and dimensions, very easy to be mounted and demounted, very easy to maintain with, very short delivery time and, of course, cheaper ones. Today commonly used commercial name for this excavator type is – compact excavator (type A, from the classification).

Compact bucket wheel excavators, compared with standard ones, have benefits as it is: far lower mass, lower purchasing price, excellent mobile capabilities, high stability, etc, but there are also some disadvantages: smaller coefficient of output in block, kugleban big stress and relatively often damage of carrying construction. It can be expected that some of those defects will be solved by further compact excavator development.

It can be said that the excavator production are in the crisis for the last two decades. Reasons for that crisis are multiple: countries transition in east Europe, drastic coal production decline because of requests reduction for electricity, etc.

The period of decreasing of produced excavators has not been used for designing of new models and their prototypes but for modernization of existing ones, Technology development in the world has positive influence on excavator manufacturers in terms of this technology implementation on excavators. It should be emphasized that on existing steel construction in the last two decades was not considerable technological improvements on its building. Besides, materials for construction had not been changed in latest decades. Steel St-52-3 is continuously unchangeable for carrying construction. On that construction the latest changes were the transition from the enchained connections with high-valuable screws and usage of welded connections in the maximal value.

In the last two decades the appliance of new technologies was only on electro-mechanical equipment. Introduction of the new, up-to-date technologies on excavators was particularly shown on the fields of:

- automatic systems of driving and control,
- intestine appliance of hydraulic systems,
- planetary gear application,
- direct drive appliance,
- considerable knowledge of logistic usage,
- significant trend of existing excavators revitalization and modernization

motora za pogon rotornog točka 3360 kW i radna masa bagera 13265 t. Sigurno je da ovako krupni i moćni rotorni bageri u skoroj budućnosti neće biti prevaziđeni. Naprotiv, zahtevi površinske eksploatacije sve su više usmereni ka bagerima relativno velikih kapaciteta, ali vrlo mobilnih, malih masa i gabarita, lakih za montažu i demontažu, jednostavnih za održavanje, sa kratkim rokom isporuke i, naravno, sa znatno manjom nabavnom vrednošću. Danas, uopšte prihvaćeni komercijalni naziv ovakvih bagera je - kompaktni bager (tip A iz klasifikacije).

Kompaktni rotorni bageri, u poređenju sa standardnim, imaju niz prednosti, kao što su: daleko manja masa, manja nabavna cena, izvanredne manevarske sposobnosti, visoka stabilnost i dr., ali i određenih nedostataka: manji koeficijent iskorišćenja u bloku, veliko opterećenje kuglbana i relativno česta oštećenja noseće konstrukcije. Za očekivati je da će se budućim razvojem kompaktnih bagera neki od ovih nedostataka eliminisati.

U poslednje dve decenije može se reći da je proizvodnja bagera u krizi. Uzroci krize su višestruki, kao što su tranzicija u zemljama istočne Evrope, drastičan pad proizvodnje uglja zbog smanjene tražnje za električnom energijom itd.

Period znatnog smanjenja proizvedenih bagera nije iskorišćen za projektovanje novih modela i prototipova, već je to vreme iskorišćeno za usavršavanje postojećih modela. Razvoj tehnologija u svetu je pozitivno uticao na proizvođače da deo tih tehnologija bude primenjen na bagerima. Treba naglasiti da na nosećoj čeličnoj konstrukciji u poslednje dve decenije nije bilo značajnih tehnoloških pomaka u njenoj izradi. Takođe, materijali za izradu konstrukcije se nisu menjali poslednjih decenija. Čelik St-52-3 je i dalje nezamenljiv za noseću konstrukciju. Na čeličnoj konstrukciji poslednje izmene su bile prelazak sa zakovanih spojeva na spojeve sa visokovrednim zavrtnjima i primena zavarenih spojeva u maksimalnoj meri.

U poslednje dve decenije primena novih tehnologija je isključivo na elektromašinskoj opremi. Uvođenje novih, savemenih tehnologija na bagerima se naročito uočava na poljima:

- sistema automatskog upravljanja i kontrole,
- intenzivnije primene hidrauličkih sistema,
- primene planetarnih reduktora,
- primene direktnih pogona,
- značajne primene saznanja iz oblasti logistike i
- izraženog trenda revitalizacije i modernizacije postojećih bagera.

Excavator equipped with control and regulation devices connected to one information system allows wide range of possibilities in terms of classical exploitation and maintenance. Excavator with accompanying equipment, the whole system respectively, are going to be equipped with sensors that main task are to change measured values in digital signals appropriate for data processing in managing units. Data processing and display of measured values allows the optimization of entire mining process on open cast mine. It is very important for complex exploitation systems with more than one excavator and stacker on them, and that are integrated in unique system. For instance, on open cast mine in Hambah in one complex system, through distribution stations, seven excavators and five stackers work at the same time. It is obvious that one so complex system is not easy to be managed by classic methods of management.

By implementation of modern communication infrastructure will be allowed optimizing of the very excavator, and optimization of range of processes in the entire system connected to maintenance and diagnostic. We will show it on excavator No-290 from Hambah. It should be mentioned that it is not classical automation of excavator operation according to function of arrow angle ($\cos\varphi$), but the entire process of mining are optimized with real quantities of mined material. Period for excavator observing was effective 1920 hours, and for that time the excavator mined 19.2 M.m3/hm with 15 % of time utilization and 93% of capacity utilization. In the mentioned period of time it is shown capacity distribution with classical excavator handling and with process of automatically handling . Classical managing has relatively wide capacity value spreading that cause range of negative things from insufficient capacity to overcharge and smothering of transporting system. Automatically capacity excavator optimization has task that current capacity has to be near the average one, i.e. that spreading of capacity value has to be minimal. By that operation the appearance of smothering, overcharging and insufficient capacity, i.e. through the longer period of time the very system is steady loaded.

Opremanje bagera uređajima za kontrolu i regulaciju sa povezivanem u jedan informacioni sistem omogućava niz prednosti u odnosu na klasično vođenje procesa eksploatacije i održavanja. Bager, odnosno ceo sistem u celini, se oprema nizom senzora čiji je zadatak da, preko prateće opreme, merne veličine pretvori u digitalne signale pogodne za obradu u upravljačkim jedinicama. Obrada i prikaz izmerenih veličina omogućavaju da se optimizira kompletan proces otkopavanja na kopu. Ovo je veoma važno kod složenih sistema eksploatacije sa više bagera i odlagača koji su integrisani u jedinstven sistem. Primera radi, na površinskom kopu Hambah u jednom složenom sistemu, preko razdelnih stanica, radi istovremeno sedam bagera i pet odlgača. Očigledno je da jedan tako složen sistem nije jednostavno voditi klasičnim metodima upravljanja.

Uvođenjem moderne komunikacione infrastrukture omogućava se optimizacija rada samog bagera, kao i optimizacija niza procesa na celom sistemu koji su vezani za održavanje i dijagnostiku. Navešćemo primer bagera No-290 u Hambahu. Napominje se da ovde nije reč o klasičnoj automatizaciji rada bagera po funkciji ugla strele ($\cos\varphi$), već se optimizira ceo proces otkopavanja sa realnim količinama otkopanog materijala. Period posmatranja bagera je bio 1920 efektivnih sati, za to vreme bager je otkopao 19.2 miliona m^3/čm sa vremenskim iskorišćenjem 51% i iskorišćenjem kapaciteta 93%. U navedenom vremenu prikazana je raspodela kapaciteta sa klasičnim upravljanjem bagera i sa automatski vođenim procesom. Klasično upravljanje ima relativno široko rasipanje vrednosti kapaciteta, što ima za posledicu niz negativnih pojava od nedovoljnog kapaciteta, do preopterećenja i zagušenja transportnog sistema. Automatska optimizacija kapaciteta bagera ima cilj da trenutni kapacitet bude što bliži prosečnom kapacitetu odnosno da rasipanje vrednosti kapaciteta bude minimalno. Takvim radom se izbegavaju pojave zagušenja, preopterećenja, nedovoljnih kapaciteta, odnosno kroz duži vremenski period sistem je ravnomernije opterećen.

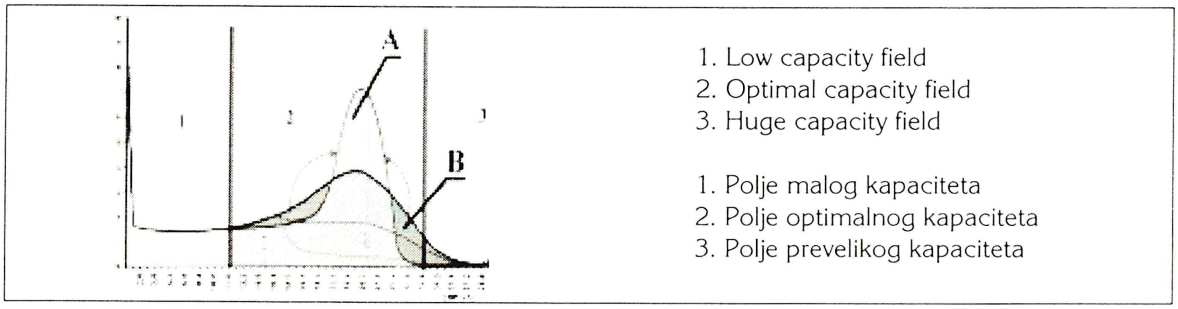


Figure 2 Capacity excavator optimization
Slika 2 Optimizacija kapaciteta bagera

Global positioning system (GPS) very quickly finds application in open cast mines. The widest use of the GPS is for geological record needs. In the last few years GPS also finds very intensive usage in the basic mechanization. Namely GPS system with increasing preciseness can very precisely appoint the excavator and stacker position, the position of rotor wheel respectively. Preciseness is shown in centimeters. On open cast mine in Hambah was applied project SATAMA based upon GPS-online technique. SATAMA project implementation costs are DM 11.5 millions, but annual savings are DM 5.3 millions. Savings are achieved by decreasing of the excavator empty run and by quality of mined coal optimization.

Hydraulic systems are used for a very long period of time on bucket wheel excavators and stackers. The use are mainly framed on accessory mechanisms where hydraulic systems has changed classical mechanical systems from what were requested very small executed speed, but big power. Those are mechanisms with periodical operations that active operation time is very short according to excavator. Those mechanisms are as follows: mechanisms for curve overcoming, delayed arrow suspension, belt conveyor tightening, caterpillar tightening, etc.

Intensive development of hydraulic components (pumps, motors, regulatory valves and especially proportional hydraulic techniques) allows the usage of hydraulic systems on the main excavator mechanisms, as it is circular excavator movement and rotor wheel arrow suspension. Circular excavator movement throughout hydraulic system is obviously taken from the excavator with one operating element with becomingly adjustment. For the excavator SchRs-630/3x25 KRUPP suggests system with the following characteristics: electromotor power 200kW, pump capacity 610 l/min, operating pressure 180 bar, with two hydro motors for moving of upper construction.

During the years on compact excavator type are installed hydraulic cylinders for holding on the rotor wheel arrow. This conception has certain disadvantages and one of the biggest is input of very big force in the zone of axial bearing.

In latest years KRUPP developed excavator (class B) with hydraulic cylinder for arrows hanging. This constructional concept excludes classical ropes system. Good hydraulic system feature are: beneficial equipment positioning, minimal mechanism mass, big specific force, easy regulation of especially transitional appearance, successful degree of efficiency, smooth operation without dynamically shocks because of small

Sistem globalnog pozicioniranja (GPS) ubrzano nalazi primenu u rudnicima sa površinskom eksploatacijom. Najrasprostranjenija primena GPS-a je za potrebe geometarskih snimanja. Poslednjih godina GPS, takođe, nalazi vrlo inenzivnu primenu i na osnovnoj mehanizaciji. Naime, sistem GPS-a sa povećanom tačnošću može vrlo precizno pozicionirati položaj bagera i odlagača, odnosno položaj rotornog točka. Preciznost se kreće i do nekoliko centimetara. Na površinskom kopu Hambah primenjen je projekat SATAMA koji se zasniva na GPS-online tehnici. Uvođenje projekta SATAMA je koštalo kop 11,5 miliona DM, ali su godišnje uštede u visini 5,3 miliona DM. Uštede su postignute smanjenjem praznih hodova bagera i optimizacijom kvaliteta otkopanog uglja.

Hidraulički sistemi već dugi niz godina su primenjeni na rotornim bagerima i odlagačima. Primena je ograničena, uglavnom, na pomoćne mehanizme, gde su hidrauilički sistemi zamenili klasične mehaničke sisteme kod kojih se zahteva mala izvršna brzina, a velika sila. To su mehanizmi sa periodičnim delovanjem, čije aktivno vreme rada je veoma malo u odnosu na efektivan rad bagera. To su sledeći mehanizmi: za savlađivanje krivina, vešanje odložne strele, zatezanje trake transportera, zatezanje gusenica itd.

Intenzivan razvoj hidrauličkih komponenti (pumpe, motori, regulacioni ventili, a posebno proprcionalne hidrauličke tehnike) omogućava primenu hidrauličkih sistema na glavnim mehanizmima, kao što su kružno kretanje bagera i vešanje strele rotornog točka. Kružno kretanje bagera preko hidrauličkog sistema je očigledno preuzeto od bagera sa jednim radnim elementom uz odgovarajuća prilagođavnja. Za bager SchRs-630/3x25 KRUPP predlaže sistem sledećih karakteristika: snaga elektromotora 200kW, kapacitet pumpe 610 l/min, radni pritisak 180 bari, sa dva hidromotora za kretanje gornje gradnje.

Već duži niz godina na bagerima kompaktnog tipa se ugrađuju hidraulički cilindri za dizanje strele rotornog točka. Ova koncepcija ima određene nedostatke, a jedan od najvećih je unos veoma velike sile u zonu velikog aksijalnog ležaja.

Poslednjih godina KRUPP je razvio bager (klase B) sa hidrauličkim cilindrom za vešanje strele. Ova konstrukciona koncepcija izbacuje klasičan sistem užadi. Dobre osobine hidrauličkih sistema su: povoljan razmeštaj opreme, minimalna masa mehanizama, velika specifična snaga, laka regulacija posebno prelaznih pojava, povoljan ukupan stepen korisnosti, mekan rad bez dinamičkih udara zbog veoma male inercije pokretnih delova, moguće

moving parts inertias, possible hydraulic breaking without wearing. Disadvantage of hydraulic system using are requests for highly educated staff in maintenance, very big dependence of equipment and hydraulic components suppliers. It should be mentioned that till now there are no significant experiences with operation of described hydraulic systems on excavator types. Figure 3 shows the same excavator type class B (excavator SchRs-630 25/3) with various arrow hangings.

hidrauličko kočenje bez habanja. Nedostaci primene hidraulike su zahtevi za visoko obučenim kadrovima u održavanju, visoka zavisnost od isporučioca opreme i od isporučioca hidrauličkih komponenti. Treba napomenuti da se za sada nemaju značajna iskustva sa radom navedenih tipova hidrauličkih sistema na bagerima. Na slici 3 prikazan je isti tip bagera klase B (bager SchRs-630 25/3) sa različitim izvođenjem vešanja strele.

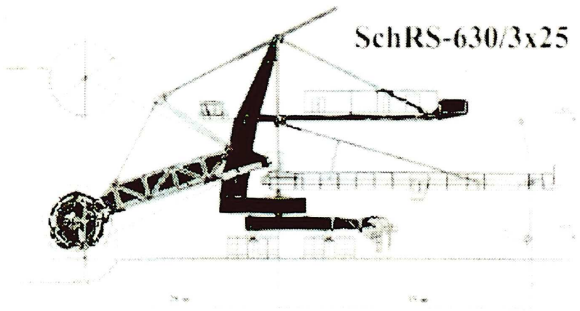
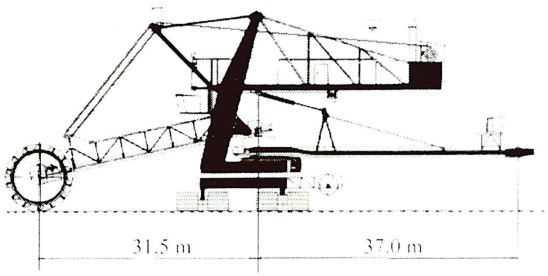


Figure 3 Arrow hanging by hydro cylinder
Slika 3 Vešanje strele putem hidrocilindra



Classical arrow hanging by ropes system
Klasično vešanje strele sistemom užadi

Importance of planet gears usage on bucket wheel excavators was more than once analyzed in different expert publications where has been analyzed advantages and faults of planet gears on excavators. In this scope of work they are mentioned just to highlight their importance for excavator use where it needs to be revitalized and modernized. Produser is in the process of excavator modernization for SRs-1300 has changed existing gears by planet ones whereby was decreased the heaviness of drive system of bucket wheel excavator for 35%. These changes are performed on excavators in Germany on open cast mine LAUBAG-Jenschvile and on excavator in Romania pit Lupoaia. In the table 3 is shown produser of proposals for gear modernization for rotor wheel drive on excavator applied in Serbia.

Značaj primene planetnih reduktora na rotornim bagerima je više puta razmatran u raznim stručnim publikacijama gde su analizirane prednosti i mane planetnih reduktora. Primena planetnih reduktora već je postala standardna oprema modernih bagera. U ovom radu su spomenuti da bi se istakao njihov značaj za primenu kod bagera koje očekuje revitalizacija i modernizacija. Proizvođač je u procesu modernizacije na bagerima SRs-1300 zamenio postojeće reduktore planetnim reduktorima čime je smanjena težina pogonskog sistema rotornog točka za 35%. Ove izmene su izvedene na bagerima u Nemačkoj na kopu LAUBAG-Jenšvalde i na bageru u Rumuniji kop Lupoaia. U tabeli 2 prikazani su predlozi proizvođača za modernizaciju reduktora za pogon rotornog točka na bagerima primenjenim u Srbiji.

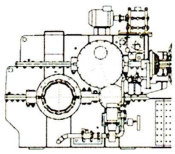
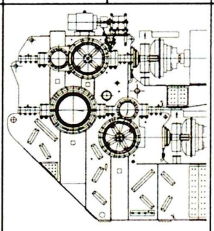
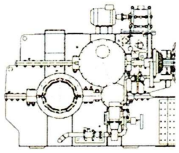
The usage of direct drives still has not found its appliance on bucket wheel excavators but it is used on bucket chain excavators. The essence of this type is that the motor is directly connected with drive shaft of head sprocket of a chain excavator. So, this drive type has any gear, what is the new approach to the operating drive of excavator organ. It is for sure that on bucket wheel excavators for a long period of time direct drive for rotor wheel movement will not be used, although the motor development with low numbers of revolution is in increasing especially for drive of big mills in the cement industry. For the needs of open cast mine Northern – Germany, Produser delivered and installed

Primena direktnih pogona još uvek nije našla primenu na rotornim bagerima ali se primenjuje na bagerima vedričarima. Suština ovog tipa pogona je da je motor direktno spojen sa pogonskim vratilom turasa vedričara. Dakle, ovaj tip pogona nema reduktor, što je nov kvalitetan pristup pogonu radnog organa bagera. Na rotornim bagerima je sigurno da se dugo neće primenjivati direktan pogon za pokretanje rotornog točka, mada je razvoj motora sa niskim brojem obrtaja u velikom usponu posebno za pogon velikih mlinova u cementnoj industriji. Proizvođač je za potrebe površinskog kopa Nohten,

two big motors for sprocket direct drive on bucket chain excavator. The excavator type is Q=14500 m^3/h, motor force P=1900 kW with revolution number of 0 to 13.34 in minute. Savings of electricity and lubricants (oil) are 522 MWh, and 2600 l, respecively.

Nemačka isporučio i ugradio dva velika motora za direktan pogon lančanika vedričara. Bager je kapaciteta Q=14500 m^3/h, a motor snage P=1900 kW sa brojem obrtaja od 0 do13.34 u minuti. Uštede u električnoj energiji su 522 MWh, a u uglju 2600 litara.

Table 1 Standardization concept for bucket wheel drives in Serbia
Tabela 1 Koncept standardizacije za radne organe u Srbiji

		1	2	3	4	5	6	7	8
		SRs1200.24/4.0		**SRs1200.22/2.0**		**SRs2000**		**SRs1300.26/5.0**	
		Original	Upgrade	Original	Upgrade	Original	Upgrade	Original	Upgrade
A	Input power	400 kW	630 kW	630 kW	630 kW	2 x 500 kW	2 x 630 kW	900 kW	900 kW
B	Motor speed	1485 rpm	1485 rpm (985 rpm) [a]	1485 rpm	1485 rpm (985 rpm) [a]	1485 rpm	1485 rpm (985 rpm) [a]	1485 rpm	1485 rpm (985 rpm) [a]
C	Bucket wheel speed	6,0 rpm	6,0 rpm	6,0 rpm	6,0 rpm	3,8 / 5,1 rpm	5,1 rpm	5,8 / 7,1 rpm	7,1 rpm
D	Gearbox weigth appr.	25 t	25 t	32 t	25 t	54 t	41 t	26 t	25 t
									

[a] ... Optional the usage of 1000 rpm motors is possible to optimize the dynamic behaviour

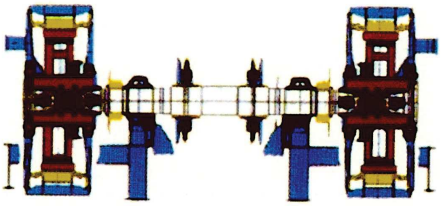
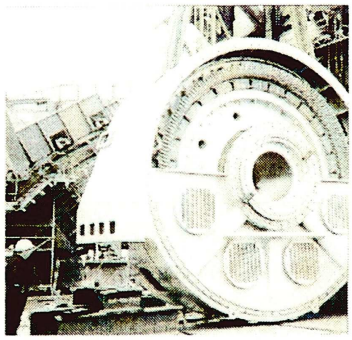


Figure 4 Schematic overview of direct sprocket chain excavat

Slika 4 Šematski prikaz direktnog pogona lančanika vedričara



Direct drive installation on bucket on bucket or chain excavator

Ugradnja direktnog pogona na bager vedričar

Especially interesting is logistic field and its use on open cast mine equipment. Installing of basic mechanization with equipment for state following in operations allows target volume tracking essential for process of maintenance. Connecting by communication network gives data that after its processing can use for maintenance backlog planning and detaining of bigger damages. Essential characterizing is that from one central place it can be followed current state of the whole excavator and system, what is very important for forehand and optimal decisions in the domain of maintenance.

As regards to maintenance reliability and capability it could be seen very big progress in excavator manufacturers production in the last two decades.

Posebno interesantno je polje logistike i primena tih saznanja na opemi površinskih kopova. Opremanje osnovne mehanizacije opemom za praćenja stanja u radu mogućava praćenje niza veličina bitnih za procese održavnja. Povezivanje komunikacionom mrežom daje podatke koji se nakon obrade mogu koristiti za planiranje zastoja održavanja i sprečavaju pojavu većih oštećenja. Bitna karakteristika je i da sa jednog centralnog mesta može sagledati trenutno stanje celog bagera i sistema, što je veoma važno za pravovremene i optimalne odluke iz domena održavanja.

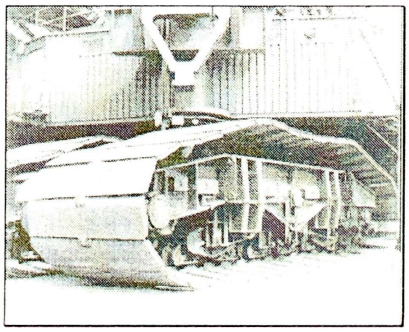
Što se tiče pouzdanosti i pogodnosti za održavnje primetan je napredak kod proizvođača bagera u poslednje dve decenije. Kod starijih bagera ne

Excavators that were produced in earlier times had not pursued requests of maintenance staffs for suitable maintenance. Very long period of time that was used for manufacturers and excavator users cooperation brought more reliability for new excavator construction than the older one. It is especially seen progress in the part of maintenance capability where it should be mentioned that new excavators are more suitable for maintenance than the older ones. To illustrate it we will mention some examples:

- carrying frem of transporting caterpillars perform so that carrying wheels can be changed without rising up of that excavator part. But for older type of excavators change of carried wheels cannot be performed without rising up of excavator and more than one day of backlog.
- rotor wheel connection with the shaft allows quicker and easier change of the whole rotor wheel in contrast to older concepts where it operation lasted for ten days.

može se reći da su uvaženi zahtevi održavaoca za pogodnim oržavanjem. Dugi niz godina saradnje proizvođača i korisnika je doprineo da su bageri novije konstrukcije veće pouzdanosti od starijih jedinica. Posebno je uočljiv napredak u delu pogodnosti za održavanje, pa se mora naglasiti da su savremni bageri daleko povoljniji za održavanje od starijih mašina. Radi ilustracije navešćemo neke primere:

- Noseći frem transportnih gusenica se izvodi tako da je noseće točkove moguće zameniti bez zadizanja tog dela bagera. Kod bagera starije konstrukcije zamena nosećih točkova nije moguća bez zadizanja bagera i višednevnog zastoja.
- Veza rotornog točka sa vratilom se izvodi tako da je moguća brza i jednostavna zamena celog rotornog točka, za razliku od starijih koncepcija kod kojih je ta operacija trajala desetak dana.



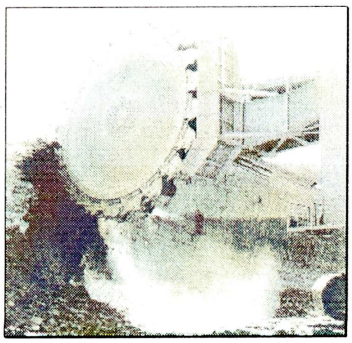


Figure 5 Frem with easy changeable carrying wheels *Easy changeable rotor wheel*
Slika 5 Frem sa lako zamenljivin nosećim točkovima *Lako zamenljiv rotorni točak*

For the latest years it was noticeable modernization trend and excavator revitalization. Achievements in this area has been very interesting for our open cast mines where more than 50% of excavators are older than 30 years. Excavator revitalization process is very complex one and mainly it can be done by common power of manufacturers and excavator users. It should be mentioned that on German, Poland, Romania and India's open cast mines revitalizations were done for large number of bucket chain and bucket wheel excavators. Effects achieved by revitalization are multiple and the most important is that by process of modernization and revitalization excavator can be prepared and rehabilitate for the next 30-40 years of reliable operations. Modernization allows us to debug weak excavator sides shown throughout exploitation and to perform much better technical characteristics in the further years. Revitalization and modernization tasks are not to change and repair wearied parts but also to increase life time and to allow utilization increasing, parts unification, cost maintenance decreasing, improvements in operating conditions,

Poslednjih godina u svetu je primetan trend modernizacije i revatilizacije rotornih bagera. Dostignuća u ovoj oblasti su veoma interesantna za naše površinske kopove na kojima je 50% bagera starije od 30 godina. Proces revitalizacije bagera je veoma složen i uglavnom se radi zajedničkim snagama proizvođača i korisnika bagera. Treba napomenuti da su na površinskim kopovima u Nemačkoj, Poljskoj, Rumuniji i Indiji obavljene revitalizacije većeg broja bagera vedričara i rotornih bagera. Efekti koji se postižu revitalizacijom su višestruki, a najvažniji je da se procesom modernizacije i revitalizacije bager pripremi i osposobi za sledećih 30 do 40 godina pouzdanog rada. Modernizacija omogućava da se otklone slaba mesta bagera uočena kroz eksploataciju i da u novom radnom veku bager ima daleko bolje tehničke karakteristike. Ciljevi revitalizacije i modernizacije ne svode se samo na zamenu i opravku dotrajalih delova, već imaju daleko veći broj postavljenih ciljeva i sastoje se, pored povećanja životnog veka, i od povećanja dozvoljenih opterećenja, unifikacije delova, smanjenja

technical characteristics improvement and mining-technological parameters improvements. On figure 6 are shown locations where modernization of equipment are to be done, proposals for modernization and expected effects according to one of leading manufacturer of bucket wheel excavators.

troškova održavanja, poboljšavanja uslova rada, poboljšanja tehničkih karakteristika i poboljšanja rudarsko-tehnoloških parametara Na slici 6 prikazane su lokacije na kojima se vrši modernizacija opreme, predlozi za modernizaciju i očekivani efekti prema jednom od vodećih proizvođača rotornih bagera i to.

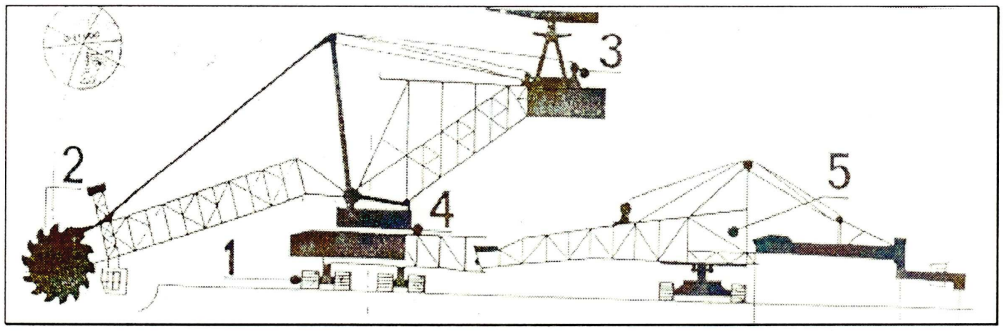


Figure 6 Revitalization amd modernization spots of excavator SRs-2000
Slika 6 Mesta revitalizacije i modernizacija bagera SRs-2000

1. Changes on cartepilar transport mechanizam drive(classical performance gears change by planetar type gears and change of drive wheels)
2. Reconstruction of mining system (classical performance gears change by planetar type gears, installation of rotor wheel with double membrane anchor)
3. Reconstruction of system for the arrow rotor wheel lifting, improvement of system with esspecialy emphasized on new breaking systems
4. Improvement on upper construction cicrcular movement system, change of toothed rim of drive gears with management modernization.
5. Loading devices revitalization (drive system change on conveyors, improvements on leading systems improvements with technological characteristic improvements)
6. Modernization of electro plant throughout of managing from the plant by computers, diagnostication by computers and safety of excavator incresing, changing of continous current power supply by powerful drive (changes of Ward-Leonard's group of thyristor regulation and even motor type changes with frequent regulation)

1. izmene na pogonima guseničnog transportnog mehanizma (zamena reduktora klasičnog izvođenja reduktorima planetnog tipa i zamena pogonskih točkova),
2. rekonstrukcija sistema kopanja (zamena reduktora klasičnog izvođenja reduktorima planetnog tipa, ugradnja rotornog točka sa duplim membranskim osloncem),
3. rekonstrukcija sistema za dizanje strele rotornog točka poboljšanje sistema dizanja sa posebnim naglaskom na nove pouzdanije sisteme kočenj a,
4. poboljšanje sistema kružnog kretanja gornje gradnje, zamena zupčastih venaca pogonskih reduktora sa modernizacijom upravljanja,
5. revitalizacija pretovarnih uređaja (zamena sistema pogona na transporterima, poboljšanje sistema vođenja uz poboljšanje tehnoloških karakteristika),
6. modernizacija elektropostrojenja kroz pogonsko upravljanje putem računara, dijagnosticiranje uz pomoć računara i povećanje sigurnosti bagera, izmena izvora napajanja jednosmernom strujom pogona veće snage (zamene Ward-Leonardove grupe tiristorskom regulacijom, a, čak, i promena tipa motora motorima sa frekfetnom regulacijom).

3. STACKERS

On this machine type for open cast mining, in the last two decades, was not seen any essential developing movements on construction or electro-mechanical equipment. It is normal that improvements on excavator equipment has its influence on improvement on stacker equipment, too. As stackers are far away simplier machines, it

3. ODLAGAČI

Na ovoj vrsti mašina za površinsku eksploataciju, u poslednje dve decenije, nisu uočena bitna razvojna kretanja u konstrukciji i elektromašinskoj opremi. Normalno je da se usavršavanje bagerske opreme odrazilo i na usavršavanje opreme odlagača. Kako su odlagači daleko jednostavnije mašine,

is easier to equipped it with devices and senzors for following operations up, and by that way to integrate them in information system. It should be highlight stacker with low focal point esspecialy adjusted for locations with strong strokes of wind. Positioning of counter sinker directly above transporting caterpillars caused low focal point.

jednostavnije ih je opremiti uređajima i senzorima za praćenje rada, a, samim tim, i integrisati u informacioni sitem. Od novijih konstrukcija treba istaći odlagač sa niskim težištem posebno prilagođenim za predele sa jakim udarima vetra. Pozicioniranje protivtega neposredno iznad transportnih gusenica postignuto je nisko težište.

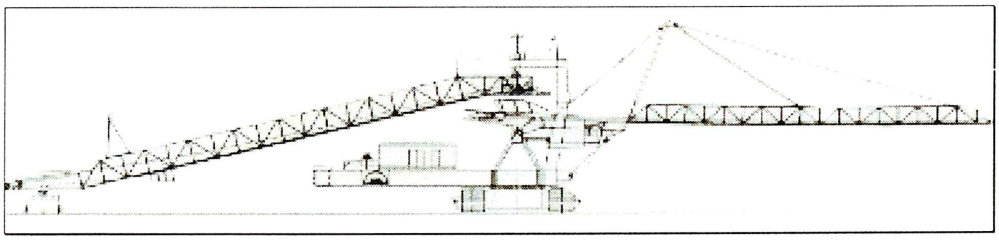


Figure 7 Stacker with low focal point
Sika 7 Odlagač sa niskim težištem

4. CONVEYORS WITH RUBBER BELT

Currently the most implemented usage for mined mass transport on lignite open cast mines has conveyors with rubber belt. There are conveyors with belt width to 3200 mm, power installed on each station till 12000 KW, with transport speed of 7.5 m/s, capacity up to 40.000 m^3/h On conveyers with rubber belt, in the last few years, a trend of very long length of conveyors with inter drive, has developed. Today the particular convenience is development of construction with curve in horizontal plane, so that the conveyors lengths reach 10 and more kilometers. The lohgest conveyor is 100 km build in 10 individual conveyors. Extensively are developed tabular (flexopipe) and under big repose conveyors.

However, on lignite open cast mines still dominates classical transporting plants. At first glance, there are no new developing tendency, but it should be emphasized that in the last two decades conveyor driving managing parts are improved considerably, as well as the all remained conveyor components. Besides, intense are studies of transparent process that shows during moving and conveyor stopping. The main requests allocated in front of new constructions are reliability system increasing, bigger units capacities, drive largeness and weight, decreasing of maintenance cost, increasing safety of operator, lower energy cost, etc.

It is for sure that the most important progress was made with frequent regulation for big power and high voltage motor drive, big capacity conveyors respectively, SIMENS delivered electro plant with frequency regulation foe conveyor as follows:

4. TRANSPORTERI SA GUMENOM TRAKOM

Danas daleko najveću primenu za transport otkopanih masa na površinskim kopovima lignita imaju transporteri sa gumenom trakom. Danas su u primeni transporteri širine do 3200 mm, instalisane snage po pogonskoj stanici do 12000 kW, sa brzinom transporta od 7.5 m/s kapaciteta do 40000 m^3/h. Kod transportera sa gumenom trakom, poslednjih godina, izražen je trend razvoja veoma dugačkih transportera sa međupogonima. Posebna pogodnost je razvijanje konstrukcija sa krivinama u horizontalnoj ravni, tako da dužine transportera dostižu 10, i više, kilometara. Najduže ugrađena transportna linija je dužine 100 km, izvedena sa 10 individualnih transportera. Intezivno se razvijaju i cevasti (flexopipe) i transporteri za transport pod velikim nagibom.

Međutim, na površinskim kopovima lignita još uvek su dominantna klasična transportna postrojenja. Na prvi pogled se ne uočava neka razvojna tendencija, ali se mora naglasiti da u poslednje dve decenije pogonski i upravljački deo transportera su zantno unapređeni, kao i sve ostale komponente transportera. Takođe, intenzivna su proučavanja prelaznih procesa koji se javljaju kod pokretanja i zaustavljanja transportera. Osnovni zahtevi koji se postavljaju pred nove konstrukcije su povećanje pouzdanosti, povećanje jediničnih kapaciteta, minimiziranje veličine pogona i težine, smanjenje cene održavanja, povećanje sigurnosti rukovaoca, niži troškovi energije i dr.

Svakako da je najvažniji napredak ostvaren sa frekfentnom regulacijom pogonskih motora velike snage i visokog napona, odnosno transportera velikih kapaciteta. SIMENS je isporučio

capacity 7500 t/h, conveyor length 2530m, belt width 2000mm, belt St-3150, belt speed 3,3 to 6,55 m/s, electromotor power 27470kW (during max. number of revolution). Wide area for number of revolution regulation and electromotor torque moment allows very soft start so that tension force in belt changes less than in classic drive with hydro dynamic connector or with sliding rings. Breaking performs also by electro way till the minimal number of revolution. We will here count the rest of advantages of this drive: speed adoption allows optimal quantity of the belt, speed reduction decrease side belt damage, soft start and breaking without slewing that allows longer period of screen drive pulleys, and by speed optimization it is possible to achieve energy savings till 20%. Besides direct effects there are some advantages in maintenance process as: there are no brushes on motors, longer operating time for gears and bearings, possible small speed allows easy inspection of rubber belt and the rest of the rotational parts.

Carrying chocks and rollers are always objects of research with two main tasks: decrease resistance motion and increase pulley operation time. MAN-TAKRAF has developed in early 1990's chock with middle roller and bigger diameter. With smaller motion resistance this construction has longer operating time and it perform lower noise. On figure 8 is shown installed construction on open cast mine Janschwalde in Laubag (Germany), where are confirmed 5000 chocks during the 2000. Middle roller diameter is 12.64" and of side ones 7.68". Specially attention is paid to the ways of packing and with it operating roller time is much bigger. On figure 7 are shown cross-section of the new construction roller. New systems for packing allows expected operating time from 30000 to 50000 hours as well as the noise minimizing. SKF recommends special bearing for rolling chocks with smaller number of balls and massive plastic cage. Mentioned bearing type gives far away bigger operating time because of semi-cleaning. Further researches has the aim to resistance coefficient of rolling pulleys reduce to value smaller than f=0,01, and now on the installed conveyor constructions resistance coefficient of rolling pulleys are between f=0,01 to 0,04 with average value of f=0,02.

Construction pulley development goes toward reliability increasing and finding a new ways for cover increase the friction coefficient. In that regard pulleys has already done with ceramic covers and friction coefficient of 0.7. The second way in pulley development are so-called „motor pulleys" where inside of them are fitted drive

elektropostrojenje sa frekfentnom regulacijom za transporter sledećih karakteristika: kapacitet 7500 t/h, dužina transportera 2530 m, širina trake 2000 mm, traka St-3150, brzina trake 3,3 do 6,55 m/s, snaga elektromotora 2470 kW (pri max. broju obrtaja). Široka oblast regulacije broja obrtaja i obrtnog momenta elektromotora omogućava veoma meki start, tako da se zatezna sila u traci menja daleko manje nego kod klasičnih pogona sa hidrodinamičkom spojnicom ili sa kliznim prstenovima. Kočenje se vrši, takođe, električnim putem do minimalnog broja obrtaja. Nabrojaćemo i ostale prednosti ove vrste pogona: podešavanjem brzine omogućava se optimalna količina materijala na traci, reduciranjem brzine smanjuju se bočna oštećenja trake, mekan start i kočenje bez proklizanja omogućavaju duži vek obloge pogonskih bubnjeva, optimizacijom brzine trake moguće je postići uštede energije i do 20%. Pored direktnih efekata prisutne su i posredne prednosti u procesu održavanja: nema četkica na motorima, duži je radni vek zupčanika i ležajeva, moguća mala brzina omogućava laku kontrolu gumene trake i ostalih rotacinih delova.

Noseći slogovi i valjci su predmet stalnog istraživanja sa dva osnovna cilja: smanjiti otpore kretanju i povećati radni vek valjka. MAN-TAKRAF je razvio početkom devedesetih godina slog sa srednjim valjkom većeg prečnika. Pored manjeg otpora kretanju ova konstrukcija ima duži vek trajanja i znatno manju buku. Na slici 8 prikazana je konstrukcija ugrađena na površinskom kopu Janschwalde u Laubagu (Nemačka), gde je tokom 2000, godine ugrađeno preko 5000 slogova. Prečnik srednjih valjaka je 320 mm a bočnih 195 mm. Posebna pažnja obraća se novim načinima zaptivanja, čime se znatno produžava životni vek valjaka. Na slici 7 prokazan je poprečni presek valjka nove konstrukcije. Novi sistemi za zaptivanja omogućili su očekivani životni vek od 30000 do 50000 sati, kao i minimiziranje buke. SKF preporučuje poseban ležaj za slogove sa manjim brojem kuglica i masivnim plastičnim kavezom. Navedeni tip ležaja daje daleko veći radni vek valjaka zbog samočišćenja. Dalja istraživanja imaju cilj da koeficijent otpora kotrljanja valjaka svedu na vrednosti manje od f=0,01, sada na izvedenim konstrukcijama transportera koeficijent otpora kotrljanja valjaka se kreće od f=0,01 do 0,04 sa prosečnom vrednošću f=0,02.

Razvoj konstrukcije bubnjeva ide u pravcu povećanja pouzdanosti i iznalaženja novih načina oblaganja u cilju povećanja koeficijenta trenja. U tom pogledu već su izrađeni bubnjevi sa keramičkim oblogama, sa koeficijentom trenja 0.7. Drugi pravac u razvoju bubnjeva su takozvani "motorni bubnjevi" kod kojih su unutar

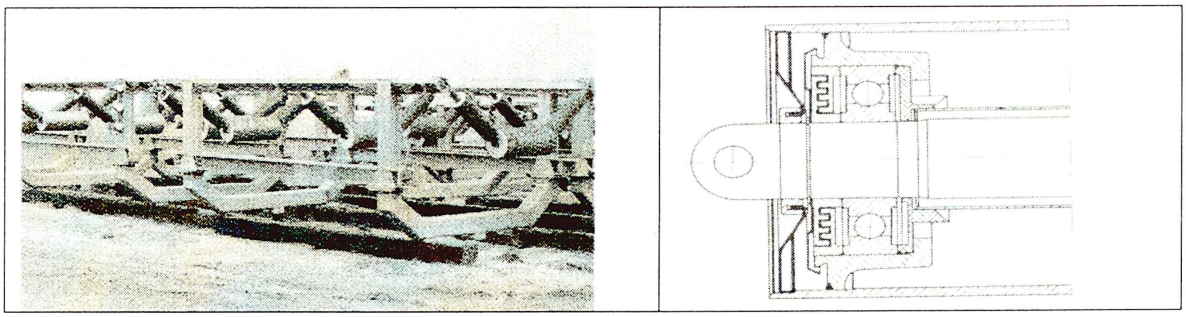


Figure 8 Conveyor construction with bigger middle pulley and pulley cross-section
Slika 8 Konstrukcija transportera sa većim srednjim valjkom, i poprečni presek valjka

motors and gears (figure 9). This systems has been used on some smaller conveyors, as well as on excavator conveyors (excavator SRs 301, Mine Lagerdorf).

bubnja postavljeni pogonski motor i reduktor (slika 9). Ovi sistemi već se primenjuju na nekim manjim transporterima, kao i na transporterima bagera (bager SRs 301, rudnik Lagerdorf).

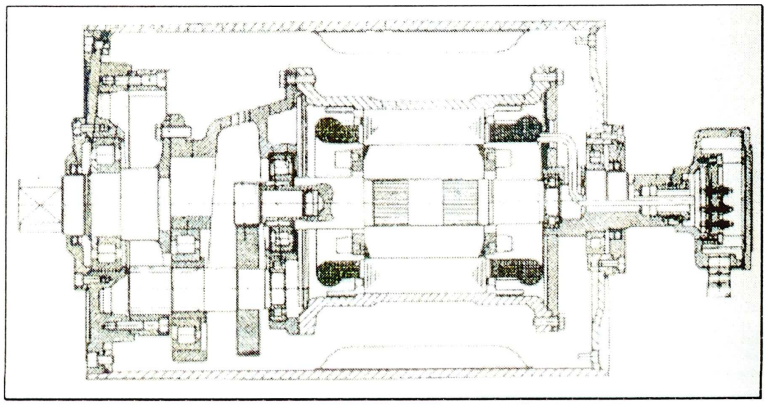


Figure 9 "Motor pulley" cross-section
Slika 9 Poprečni presek "motornog bubnja"

There, also, are new breaking systems on conveyors. For instance, installing of discus breaks on conveyors instead of classical drum break. The illustration is on the open pit mine Hambah where more than 30% of disk brakes on drive have been changed by classic drum brakes

Na transporterima primenjuju se i novi sistemi kočenja, kao, na primer, ugradnja disk kočnice na transporterima umesto klasične dobošne kočnice. Primer je površinski kop Hambah, gde je preko 30% kočnica sa diskom zamenilo dobošne kočnice.

The new solutions find in cleaner constructions. One of very good solutions is construction of cleaner "SAF-2" from US Company Martin (figure 10). The board for cleaning consists of flexible segments allocated on special stand that allows very fast and easy change, and cleaning effects are very good with minimal risks for belt damage.

Iznalaze se nova rešenja i konstrukcije za čišćenje. Jedan veoma uspešno izveden primer je konstrukcija čistača "SAF-2" američke firme Martin (slika 10). Daska za čišćenje sastoji se iz fleksibilnih segmenata koji su postavljeni u posebnom postolju koje omogućava veoma brzu i laku zamenu, a efekti čišćenja su veoma dobri uz minimalne rizike za oštećenje trake.

Development of carrying plies goes in two different ways: ply production of special highly resistant materials against tearing, and this materials are on armid base, of kevlar respectively. The second way is in equipping inside belt construction by different plies resistant to permeability.

Razvoj nosećih uložaka trake ide u dva osnovna pravca: izrada uložaka od posebnih materijala visoko otpornih na kidanja, to su materijali na bazi aramida, odnosno kevlara. Drugi pravac, je opremanje unutrašnje konstrukcije trake raznim zaštitnim ulošcima otpornim na proboje.

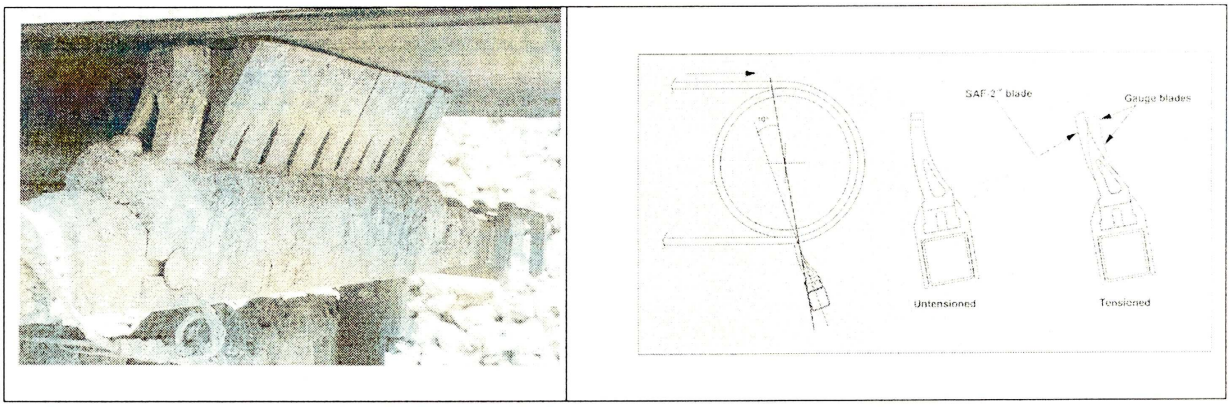
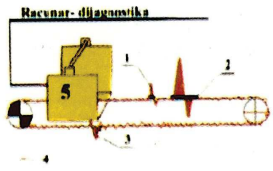


Figure 10 "SAF-2" cleaner construction
Slika 10 Konstrukcija čistača "SAF-2"

The belts are equipped with sensors for initialization belt damage detection. Exploitation problems occur on this belt types are still big, so, that performances are not accepted from users. The more interesting are researches of existing, well known, devices for metal detection used for early detection of belt with steel fuse damages. Operating principle is to change magnetic field after belt damage and compared with the previous state. This device needs computer support that compare earlier belts state. Precision of this device is in the volume range of few centimeters, what is more than suitable. This kind of system has been installed and operates successfully on open cast mine Hambah, No-293 excavator (the system has been installed during the 1998), and is shown by scheme on the figure 11.

Trake se opremaju senzorima za otkrivanje inicijalnih oštećenja trake. Eksploatacioni problemi koji se javljaju kod ovih vrsta traka su još uvek veliki, tako da takva izvođenja nisu opšte prihvaćena kod korisnika. Interesantna su istraživanja da se postojeći, poznati, uređaji za detekciju metala koriste za rano otkrivanje oštećenja trake sa čeličnim kordom. Princip rada se zasniva na promeni magnetnog polja posle oštećenja trake i poređenjem sa prethodnim stanjem. Ovaj uređaj zahteva podršku računara koji poredi prethodna stanja trake. Preciznost ovog uređaja je reda veličine nekoliko santimetara, što je više nego zadovoljavajuće. Ovakav sistem je ugrađen i uspešno radi na bageru No-293 na nemačkom kopu Hambah (sistem je ugrađen tokom 1998. god.) i šematski je prikazan slikom 11.



1. Metal piece
2. Belt connection
3. Belt damage
4. Normal detector signal output
5. Metal detector

1. Metalni komad
2. Spoj trake
3. Oštećenje trake
4. Normalan izlazni signal detektora
5. Detektor metala

Figure 11 Belt damage detecting by metal
Slika 11 Otkrivanje oštećenja trake sa detektorom metala

Particular attention in belt conveyor development are paid to continual following and control of conveyor operations – belt leading with active regulation system, control system introduction against belt tearing, sliding or tightening control, bearing temperature control, vibration control, and so on, as well as mass discharge and coal quality control. It is shown, on figure 12-a,

Posebna pažnja u razvoju transportera posvećuje se stalnom praćenju i kontrali rada transportera - vođenje traka sa aktivnim sistemom regulacije, uvođenje sistema kontrole protiv cepanja trake, kontrole proklizavanja ili zatezanja, kontroli temperature ležajeva, vibracija i dr., kao i merenju protoka (mase) i kvaliteta uglja. Na slici 12-a

sensor installed on drive group for vibration measurements, and on figure12-b shown is installed "on-line" analyzer for coal quantity measuring.

prikazan je senzor ugrađen na pogonskoj grupi za merenje vibracija, a na slici 12-b ugrađeni "on-line" analizator za merenje kvaliteta uglja.

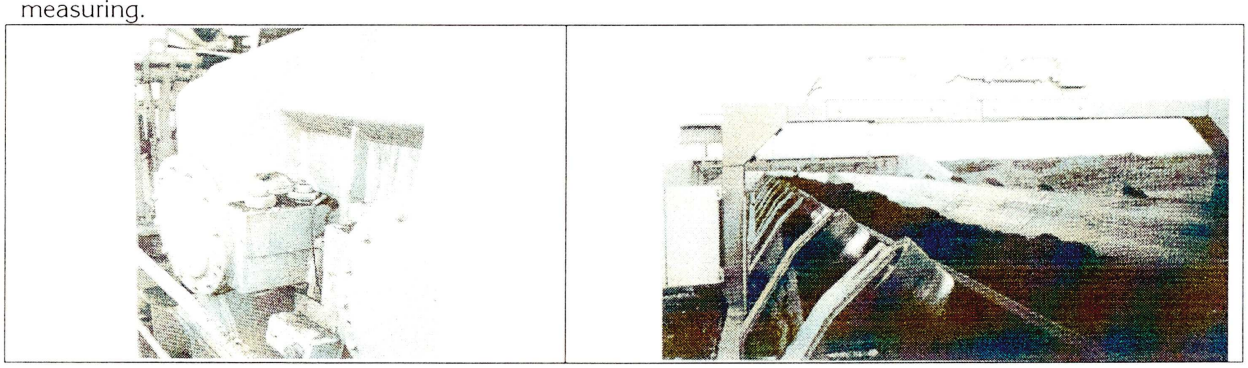


Figure 12 Vibration measuring sensors on drive (a) and installed "on-line" analyzers (b)
Slika 12 Senzori za merenje vibracija na pogonu (a) i ugrađeni "on-line" analizatori (b)

5. CONCLUSION

In the last years parallel with open cast mine exploitation system development it has noticed intensive mechanization development, and according to it some emphasis on up-to-date constructions, quality materials, modulated equipment installation are noticed, and everything in the aim of maximal production and economical effects achievements, on maintenance operating and costs minimizing, decreasing of power generation costs, maximal safety progress, and as well as ecological issues solving.

Our mines and machine building industry (users, operators and equipment manufacturers) had to done big efforts "to follow on steps" with modern tendencies in this mechanization development and using, to allow optimal conditions for further exploitation on our open cast mines and to avoid a greater dependent on import.

5. ZAKLJUČAK

Poslednjih godina uporedo sa razvojem sistema površinske eksploatacije intezivno se razvija i mehanizacija, pri čemu je naglasak na primeni savremenih konstrukcija, kvalitetnih materijala, modularnoj ugradnji opreme i dr., a sve u cilju postizanja maksimalnih proizvodnih i ekonomskih efekata, minimiziranja radova i troškova na održavanju, smanjenju utroška energije, postizanju maksimalne sigurnosti, kao i zaštite okoline.

Naši rudnici kao i mašinogradnja (korisnici, održavaoci i proizvođači opreme) moraju učiniti napor da "uhvate korak" sa savremenim tendencijama u razvoju i korišćenju ove mehanizacije, kako bi se omogućili optimalni uslovi za dalju eksploataciju na našim površinskim kopovima i izbegla prevelika zavisnost od uvoza.

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