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THE ROLE OF MAINTENANCE IN LOGISTIC SERBIAN OPEN PITS MINE

ULOGA ODRŽAVANJA U LOGISTICI POVRŠINSKIH KOPOVA SRBIJE

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Abstract: *This article presents the possibilities of aplication Logistics on the Lignite open pits mines in Serbia. These possibilities are significant on the area of improvement the existing condition of maintainance, providing spare parts, financials, information systems. It presents an example of metodology of finding the weak points of the installations.*

Key words: *logistic, open pits mine, weak points*

Abstract: *U članku se prikazuju mogućnosti primene logistike na površinskim kopovima lignita u Srbiji. Te mogućnosti su značajne na području unapređenja postojećeg stanja u pogledu sistema održavanja, obezbeđenja rezervnih delova, informacionog sistema, finansijske oblasti, itd. Dat je primer o slabim mestima postrojenja.*

ključne reči: *logistika, površinski kop, slaba mesta*

1 INTRODUCTION

Logistics made its appearance as a discipline of the military studies in the United States. It was defined then as a part of military sciences, which deals with military motions, supplying and providing for military troups. (Websteržs New Universal Dictionary, New York 1977). In civil applications there are many significiant specifics.The basic idea is to deliberatly ensure the whole support for a tehnical system, resulting with the most efficient performing . In civil applications Logistics is the art and the science of managment, engineering, and other activities that refer to defining the demands, projecting, supplying and maintaining technical systems, with the duty to ensure the realization of business aims and plans. There are also some other definitions of Logistics. From everything that has been said follows, anyway, that Logistic is one many-sided support for a technical system, which means: providing spare parts, working materials, instruments for transport and comunications, the maintainance and providing for currecnt asses, finances etc,. In one word, it deals with everything

1 UVOD

Logistika je nastala kao disciplina vojnih nauka u Sjedinjenim Američkim Državama. Tada je definisana kao deo vojne nauke koja se bavi pokretima, snabdevanjem i zbrinjavanjem trupa (Websteržs New Universal Dictionary, New York, 1977). U civilnim primenama ima značajne specifičnosti. Osnovna ideja je da se osmišljeno obezbedi svestrana podrška jednom tehničkom sistemu radi što uspešnijeg funkcionisanja. U civilnim primenama logistika je veština i nauka poslovnog upravljanja (menadžmenta), inženjerstva i drugih aktivnosti, koje se odnose na definisanje zahteva, projektovanje, snabdevanje i održavanje tehničkih sistema, tako da se obezbedi ostvarenje poslovnih ciljeva i planova, odnosno njihovo poslovno funkcionisanje. Ima i drugih definicija logistike. Iz svega ipak proizilazi da se logistika bavi svestranom podrškom jednom tehničkom sistemu, a to znači: obezbeđenjem rezervnih delova, pogonskih materijala, sredstava za transport i komunikacije, održavanjem, obezbeđenjem obrtnih sredstava, finansijama itd., dakle, sve ono što treba

that must ensure successfull and economical functioning of technical systems. It also means that logistics is not limited on elements of tehnical caracteristics (productions, service and similar), but also deals with questions of personnel and their training, envirovmental conditions, etc.

It can be seen that logistics refers to all system factors. Besides that, logistical approach examines system at every stage of its living series, which can comparatively be classified into the following stages: 1. working out the idea and defining project taskl, 2. idealistic solution, 3. designing and constructing, 4. production and construction of the system, 5. service of the built system and maintainnance of it, which includes not only restoring its original technical condition, but also reconstructions, modernizations and other improvements.

For the construction of the new open pits mine or opening a new field on already existing open cast mining, the project of logistics, within the subprojects, must solve many questions, while the most important of them are the following:

The Maintainance project in the meaning of strategy, technology, organization, and also from the point of support the cooperation with other firms for certain jobs. This also includes designing maintainance workshops, defining necessary machines and devices, workshop areas, necessary workers by structure and qualifications, infrastructures, warehouses, and other technical elements.

The project of supplying spare parts, purchase and manufacturing in proper workshops. System must be flexible in the case of various problems such as damages in proper workshops, and other possible enviromental, quality, price, delivery deadline and other deviations.

The Labour project, which defines a number and proffesion of workers, based mainly on the knowledge of each, and not formal qualifications. Usually, additional educatation is requested for certain working places.

Information system project on works, damages, maintainances and failure of other kind. Information system is a base for corrections actions and improvements of the whole system. This should make possible to escorte each event in the system during the work, as to give the information for analysing reliability, maintainbility, and correction of logistics system itself in use.

da obezbedi uspešan i ekonomičan rad tehničkih sistema. To, dalje, znači da se logistika ne ograničava na elemente tehničkog karaktera (proizvodnja, održavanje i sl.), već se bavi i pitanjima kadrova i njihove obuke, uslovima okruženja i sl.

Već iz rečenog je vidljivo da se logistika odnosi na sve domene koji utiču na sistem. Osim toga logistički pristup posmatra sistem u svim fazama njegovog životnog ciklusa, koji se uslovno može rasčlaniti na sledeće: 1. razrada idejnog rešenja i definisanje projektnog zadatka, 2. idejni projekat, obično u varijantama, koje se razrađuju do stepena kada je moguće odabrati najpovoljniji, 3. projektovanje i konstruisanje, 4. proizvodnja i izgradnja sistema i 5. eksploatacija izgrađenog sistema, pri čemu se kroz godine eksploatacije održavanje ne sastoji samo u obnavljanju prvobitnog tehničkog stanja, već se vrše i rekonstrukcije, modernizacije i druga unapređenja.

Za izgradnju novih kopova ili otvaranje novog polja postojećeg površinskog kopa, projekat logistike treba u okviru podprojekata da reši niz pitanja, od kojih su najvažnija sledeća:

Projekat sistema održavanja u pogledu strategije, tehnologije, organizacije, kao i sa stanovišta oslanjanja na druge firme za pojedine poslove. U ovo spada i projektovanje i radionica za održavanje, definisanje potrebnih mašina i uređaja, površine radionica, radne snage po strukturi i kvalifikacijama, infrastrukture, skladišta i drugih tehničkih elemenata.

Projekat snabdevanja rezervnim delovima, nabavka i izrada u sopstvenim radionicama. Sistem treba da bude fleksibilan s obzirom na moguće kvarove u sopstvenim radionicama i na moguće promene u okruženju, u pogledu kvaliteta, cena, rokove isporuke i sl.

Projekat radne snage, kojim se definiše broj i struka izvršilaca, oslanjajući se na znanje svakog pojedinca koji treba da se primi, a ne formalne kvalifikacije. Obično je potrebno i dopunsko edukovanje za pojedina mesta.

Projekat informacionog sistema o radu, kvarovima i održavanju i zastojima druge vrste. Informacioni sistem je osnova za korektivne akcije radi poboljšanja rada sistema. On treba da omogući uvid u sve što se na sistemu događa tokom rada, da bi se mogla analizirati pouzdanost, pogodnost za održavanje pojedinih celina i sklopova, kao i za korekciju samog logističkog projekta u primeni.

Besides these four basic projects, depending on the nature of technical system, it must also take into consideration the problems of construction locations, effects on the enviroment, procedure at the end of the life cycle (reconstruction, discard, recycling, etc).

2 APPLICATION OF LOGISTICS ON OPEN PITS MINES IN SERBIA

In Serbia two bigger lignite open pits mines are in use: Kolubara, with pits Barosevac (with the capacity of about 2 10^6 tones per year), Polje - D (cca 15 10^6 tones per year), and Tamnava - Zapadno polje (cca 6 10^6 tones per year), and Kostolac with pits Klenovnik (cca 0,3 10^6 tones per year) , Cirikovac (cca 1,5 10^6 tones per year) and Drmno (cca 6,5 10^6 tones per year). Some of them are in the final stage of exploitation,and some are in the phase of expanding capacity, (these problems will not be dealt with here) .

Logistics is not systematically used on open pit mines in Serbia. Mines were opened in the earlier period of time, so many logistics principles, described at the beggining of this article, cannot be applied, exept in cases of some changes, additions and improvements of the existing situation. There are a lot of other problems standing like barrier for wider practical use of Logistics. Coal exploated from theses mines, deliverd to Power stations, does not have economic price, so the mines have a poor economic position. The Logistics principles developed for the United States Army and further appllied in civil industry of large and rich companies, have so much greater potentialities compared with the poor Serbian Lignite open pits mines, so the same method of thinking and deciding cannot be used. Mines in Serbia are led by good engineers, but without education in Logistics (sciences), in present as well as ten to twenty years before.

In close future very few new open pits mines will start running in Serbia, which can be more or less said for the whole Europe. That's why applicaton of Logistic procedure finds its place only on already existing mines, considering that the stages of the life cycle are concluded (idealistic project, production and system construction), and that it only stays to focuse attention on the stages of exploatation, substituting the old machines with the new ones, and similar. That means that it is necessary to logistically analyse, in order to improve, essential segments of the existing conditions: exploation existing mine machines tecnology, transport and processing (vast disposal),

Osim ova četiri osnovna projekta, zavisno od prirode tehničkog sistema potrebno je obuhvatiti i problematiku lokacije izgradnje, uticaj na okolinu, postupke na kraju životnog ciklusa (rekonstrukcija, otpis, reciklaža), itd.

2 PRIMENA LOGISTIKE NA POVRŠINSKIM KOPOVIMA SRBIJE

U Srbiji su u radu dva veća ugljena basena sa površinskom eksploatacijom: 1.) Kolubara, sa kopovima Baroševac (kapaciteta cca 2 10^6 t/god.), Polje D (cca 15 10^6 t/god) i Tamnava - Zapadno polje (cca 6 10^6 t/god) i Kostolac sa kopovima Klenovnik (cca 0,3 10^6 t/god), Ćirikovac (cca 1,5 10^6 t/god) i Drmno (cca 6,5 10^6 t/god). Neki od ovih kopova su u fazi završetka eksploatacije, a neki u fazi povećanja kapaciteta; o toj problematici ovde neće biti reči; o tome je dosta pisano.

Logistika nije sistematski primenjena na tim kopovima. Kopovi su otvoreni u ranijem periodu, te se mnogi sadržaji logistike, opisani u uvodu ovog članka ne mogu ni primeniti, osim kao izmene, dopune i poboljšanja postojećeg stanja. Na putu većoj praktičnoj primeni logistike stoje još i brojni činioci. Ugalj koji se isporučuje elektranama sa ovih kopova nema ekonomsku cenu, te rudnici imaju skroman ekonomski položaj. Logistika razvijena za vojsku SAD i primenjena u civilnoj industriji velikih i bogatih kompanija raspolaže neuporedivim mogućnostima prema siromašnim kopovima u Srbiji, pa je logika razmišljanja i odlučivanja drugačija. Rudnike u Srbiji vode dobri inženjeri, ali, sigurno, do pre 10 i 20 godina, pa ni danas nisu edukovani u ovom pravcu.

Malo koji novi površinski kopovi uglja će se otvoriti u Srbiji u dogledno vreme, što uostalom uglavnom važi za celu Evropu. Primena postupaka logistike zato ima mesta na postojećim rudnicima imajući u vidu da su delovi životnog ciklusa prošli (idejni projekat, proizvodnja i izgradnja sistema) i da ostaje da se pažnja usredsredi na fazu eksploatacije (zamenu starih mašina novim isl.). To znači da je potrebno da se logistički analiziraju, u cilju poboljšanja, bitni segmenti postojećeg stanja: tehnologija eksploatacije postojećih mašina za otkopavanje, transport i preradu, odnosno odlaganje jalovine, sistem održavanja u pogledu tehnologije i organizacije, snabdevanje rezervnih delova i materijala, informacioni sistem i čitav niz drugih postojećih procedura.

maintainance system in the aspect of technology and organization, providing spare parts and materials, informaton system, and many other existing procedures.

However, it is evident that Logistics has a great potentiality of being applied on Lignite open pits mines in Serbia. It is necessary to logistically analyse and improve many segments, of which we shall stress the following:

a) System for the supply of the spare parts for working machines in the pits mine system, with the improvement of production. For excavators, stackers and conveyors with rubber belt, - Kolubara-metal produces over 90% of necessary parts. Production economy, manufacturing speed, ect.
b) Information systems in both mines (Kolubara and Kostolac) must be cosiderably improved. The current mode of collecting information on elements of Logistics is not satisfying. There is no clear understanding of what has happen in exploitations nor in maintainances, and there is no corresponding analysis of the events nor corresponding conclusion. Collecting relevant inforrmation on work and maintainance of the system and their transformation into relevant information and analysis is a base for high reliability and safety of the system functioning.
c) Education and training of operators and maintainers of device must be advanced, too. For example, operators of exavators must obtain much more serious training and education.
d) Advancement of maintainance organization and applying of a new diagnostics technology and work technology is needed, too.
e) Analysis of trafic functionality on the open pits mines, for supply, health care and fireman vechiles, etc.
f) Installing a more sophisticated way for defining weak spots of the system, with the aim of eliminating them.
g) The management area.
h) The financing area.

3 ABOUT PROBLEMS OF THE WEAK POINTS ON THE MACHINES

All of these mentioned segments must be determined in the aspect of mutually integrated models. The more detailed discussion of

U odnosu na iznesenu problematiku i u odnosu na postojeće stanje na površinskim kopovima u Srbiji, može se zaključiti da logistika ima značajan prostor za primenu. Potrebno je da se u logističkom maniru analiziraju i unaprede mnogi segmenti, od kojih navodimo samo sledeće:

a) Sistem obezbeđenja rezervnih delova za rad mašina na kopu, uz unapređenje sopstvene proizvodnje; za bagere i odlagače i transportere sa gumenom trakom u Kolubara metalu se proizvodi preko 90% potrebnih delova; ekonomičnost proizvodnje; brzina izrade, itd.
b) Informacioni sistem u oba basena (Kolubara i Kostolac) moraju biti bitno unapređeni. Sadašnji način prikupljanja podataka o elementima logistike na zadovoljava ni u pogledu jasnog uvida šta se dogodilo u eksploataciji ni u održavanju, ni u pogledu analize događaja i zaključivanja. Prikupljanje podataka o radu i održavanju sistema i njihove transformacije u relevantne informacije i analize, predstavljaju osnovu visoke pouzdanosti i sigurnosti funkcionisanja sistema.
c) Školovanje i obuka rukovalaca i održavalaca opreme mora se unaprediti. Primera radi, rukovaoci bagerima moraju dobiti znatno ozbiljnije obrazovanje i obuku.
d) Potrebno je unapređenje organizacije održavanja i primena novih tehnika dijagnostike i tehnologije rada.
e) Analiza funkcionalnosti saobraćajnica (pristupnih puteva) na kopu, za snabdevanje, sanitetska i vatrogasna vozila, itd,
f) uvođenje sofisticiranijeg načina definisanja slabih mesta na sistemu, u cilju otklanjanja,
g) oblast upravljanja i
h) oblast finansija.

3 O PROBLEMATICI SLABIH MESTA NA MAŠINAMA

Svaki od navedenih segmenata treba da se reši u vidu međusobno integrisanih modela. Detaljnije razmatranje istih celina daleko prevazilazi mogući okvir rada ove vrste. Zato se ograničavamo na razmatranje nekih aspekata primene slabih mesta na mašinama.

mentioned segments highly exceeds the limits of the work of this kind. Because of that, we will discuss only some aspects of application of the weak points.

Based on following the appearances of damages on machines, for example system Excavator-conveyor-stacker, after a certain period of time, by simple analysis is concluded how much each of the construction system totality participates in total damages. It is much more delicate problem how to decide on the base of mentioned information,

There are many methodologies for identifying the weak points. We think that one of the most suitable is the method developed on the Faculty of Mining and Geology in Belgrade. In this methodology evaluation of the weak points is based on determing the costs caused by damaging any of the j – system elements, including the value of lost production and costs of maintenance.

If the system is divided on n number of elements ($j = 1, 2, \ldots, n$) , then each of them (j – element) in observed period of time T_1 , causes failures in the production, because of damages and costs of maintenance for eliminating damage. .Costs of utilizing (Cj) for j – element in the period T_1 , converted in money, are:

$$Cj = D \cdot Kj + \frac{Coj}{T_1}, \qquad (1)$$

D [money unit / hour] - value of system work, market value of the product,
Tr [hour] – efective time in working of the system, in observed period of time,
Coj – costs of maintainance of the j – element, in observed period of time,
Kj – coefficient of failure of the j - element, defined as :

$$Kj = \frac{\sum_{i=n}^{i=m} t_{ij}}{T_1}, \qquad (2)$$

m – number of damages that have occured in the observed period of time,
t_{ij} – time of duration i – damage on the j - element $(m = 1, 2, \ldots i, \ldots m)$.

Value of system work *(D)* is not simple to determine, especially because it must be determined for the whole open pit mine, considering that only coal system is producing for the market , while market value is low.

Na osnovu praćenja kvarova na mašinama, npr. sistema BTO, posle određenog perioda, jednostavnom analizom se utvrđuje koliko koja konstrukciona celina učestvuje u ukupnim kvarovima. Mnogo je delikatniji problem kako na osnovu tih informacija da se odlučuje.

Ima više metodologija za traženje slabih mesta. Nama se prikladnom čini ova, razvijena na RGF u Beogradu. U ovoj metodologiji vrednovanje slabih mesta zasniva se na određivanju troškova koje sa sobom nose kvarovi bilo kog j – tog elementa sistema, uzimajući u obzir vrednost izgubljene proizvodnje i troškove održavanja.

Ako je sistem podeljen na n elemenata ($j = 1, 2, \ldots, n$), onda svaki, j – ti element u posmatranom periodu praćenja T_1 izaziva zastoje u proizvodnji zbog kvarova i troškove održavanja radi otklanjanja kvara. Troškovi korišćenja *(Cj)* za j – ti elemnt u periodu T_1 , izraženo u novcu iznose:

$$Cj = D \cdot Kj + \frac{Coj}{T_1}, \qquad (1)$$

D [novčana jedinica/h] - vrednost rada sistema, tj. tržišna vrednost ostvarenog proizvoda,
Tr [h] – efektivno vreme rada sistema u periodu praćenja,
Coj – troškovi održavanja j – tog elementa u periodu praćenja,
Kj – koeficijent otkaza elementa j , dat izrazom:

$$Kj = \frac{\sum_{i=n}^{i=m} t_{ij}}{T_1}, \qquad (2)$$

m – broj kvarova koji se dogodio u vreme posmatranja;
t_{ij} –vreme trajanja i – tog kvara na elementu j $(m = 1, 2, \ldots i, \ldots m)$.

Vrednost rada sistema *(D)* nije jednostavno odrediti, pošto je treba utvrditi za ceo površinski kop, s obzirom na to da samo ugljeni sistemi proizvode za tržište, dok je vrednost otkopane jalovine mala.

Izraz (2) može da se raščlani na nekoliko komponenata troškova održavanja, kako bi se pojedine komponente mogle posebno pratiti, što bi pomoglo da se adekvatno odaberu mere

Expression (2) can be devided into several maintenance costs components, so that some single components could be particularily observed. This could help to adequatly choose measures that should be taken for eliminating weak points. Expression (1) can be written as:

$$Cj = \frac{D}{T_1}\sum_{i=1}^{i=m} t_{1ij} + \frac{D}{T_1}\sum_{i=1}^{i=m} t_{2ij} + \frac{Cdi}{T_1} + \frac{Csj}{T_1}, \quad (3)$$

t_{1ij} – technical time for i – repairing of j - element, that is the time for direct work on repairing,

t_{2ij} - organizaton time for i – repairing of j - element, (time for waiting team of workers for repairing, and also waiting of equipments, spare parts, etc.),

Cdi – value of spare parts, spent for maintenance of j – element in observed period of time and

Csj – other costs of maintenance for j – element, in observed period of time.

According to what has been said, from the the mining system users point of view,the weak point is a machine, complex, or a part of the process, whose exploitation is followed with the unfavourable consequences, expressed in the losses in production because of the failures, and costs of maintainance beyond the level acceptable for the users.

Division on n – number of system elements should be made so that each of them presents a constructonal totality, because the measures that should be taken in order to remove the weak spots, in the first place can be related to such totalities.

4 CONCLUSION

Serbia is an important space for the wider use of logistics on open pits lignite mines. It refers on the first place on the possibilities for improvement of the main segments of the existing conditions, such as maintenance system, providing spare parts, information system, financial problems, etc. Each of these fields has to be deliberately viewed and projected. Supplement of that is given on weak points of the installation.

koje treba preduzeti radi otklanjanja slabih mesta. Izraz (1) se može napisati kao:

$$Cj = \frac{D}{T_1}\sum_{i=1}^{i=m} t_{1ij} + \frac{D}{T_1}\sum_{i=1}^{i=m} t_{2ij} + \frac{Cdi}{T_1} + \frac{Csj}{T_1}, \quad (3)$$

gde je:

t_{1ij} – tehničko vreme i – te opravke elementa j, tj. vreme neposrednog rada na opravci,

t_{2ij} - organizaciono vreme i – te opravke elementa j, (vreme čekanja ekipe radnika koji rade opravku, čekanje mehanizacije, rez. delova i sl.),

Cdi – vrednost rezervnih delova utrošenih pri održavanju elementa j u periodu posmatranja i

Csj – ostali troškovi održavanja na elementu j u periodu posmatranja.

Na osnovu izloženog, sa gledišta korisnika sistema u rudarstvu, slabo mesto predstavlja mašina, sklop, ili deo procesa, čija je eksploatacija praćena nepovoljnim posledicama izraženim u gubicima proizvodnje zbog otkaza i troškovima održavanja iznad nivoa koji je za korisnike prihvatljiv.

Podela na n elemenata sistema treba da se izvrši tako da svako od njih predstavlja konstrukcionu celinu, jer mere koje treba da se preduzmu u cilju otklanjanja slabih mesta prvenstveno mogu da se odnose na takve celine.

4 ZAKLJUČAK

Logistika ima značajan prostor za veću primenu na površinskim kopovima lignita u Srbiji. To se, pre svega, odnosi na mogućnosti unapređenja bitnih segmenata postojećeg stanja, kao što su sistem održavanja, snabdevanje rezervnim delovima, informacioni sistem, finansijska problematika, itd. Svako područje navedene problematike mora da se osmišljeno sagleda i projektuje. Prilog tome je dat o slabim mestima postrojenja.

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