COMPARISON OF TECHNOLOGIES FOR THE RAILWAY SUPERSTRUCTURE OVERHAUL IN THE CONTEXT OF THE SERBIAN RAILWAYS

UPOREĐENJE TEHNOLOGIJA ZA REMONT GORNJEG STROJA PRUGA U KONTEKSTU ŽELEZNICA SRBIJE

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Summary: Depending on the needs of the investor, the dynamic plan, the quantity of works and the economic feasibility, there are several different methods of carrying out the railway superstructure works replacement - the dismantling and re-assembly of the track. The paper presents the analysis of the existing and available techno-logies for overhaul works and recommendation of the appropriate one for conditions and constraints at the Serbian railways.

Keywords: railway superstructure, overhaul, technology, equipment

Rezime: U zavisnosti od potreba investitora, dinamičkog plana, količina radova i ekonomske opravdanosti, postoji nekoliko različitih načina zamene gornjeg stroja železnica - demontaže i ponovne montaže koloseka. Rad prikazuje analizu postojećih i raspoloživih tehnologija za radove remonta i preporuku odgovarajuće u odnosu na uslove i ograničenja na železničkim prugama u Srbiji.

Ključne reči: gornji stroj pruga, remont, tehnologija, oprema

1. INTRODUCTION

The overhaul or main repairs of the railway superstructure are performed when it is no longer possible to provide safe rail traffic with regular maintenance works. Overhaul works include the replacement of all track parts with new ones (worn rails, sleepers, fasteners and fittings), while the ballast is cleaned and replenished with a crushed stone or completely replaced with a new crushed stone, depending on how slurried it is [1]. The overhaul of the superstructure is, as a rule, performed under track closure and with a restriction on the speed of

1. UVOD

Remontu ili glavnim opravkama gornjeg stroja pruge se pristupa kada radovima na tekućem održavanju više nije moguće obezbediti siguran šinski saobraćaj. Radovi remonta obuhvataju zamenu svih delova koloseka novim (istrošene šine, pragovi, pričvrsni i spojni pribor), dok se zastorna prizma čisti i dopunjuje tucanikom ili potpuno zamenjuje novim tucanikom, u zavisnosti od stepena zaprljanosti [1].

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trains. The key position of the overhaul of the superstructure - the replacement of the railway track panel i.e. its disassembly and re-assembly, can be carried out in several ways, depending on the:

- requirements of the employer,
- works schedule,
- quantity of works, and
- economic feasibility.

For a long time, the maintenance and overhauling works of the railway superstructure were done manually, primarily because of the intense railway traffic and the inability to close them for a sufficient period of time. This was the basic prerequisite for the use of mechanization [1]. The situation has significantly improved in the last 50 years. Today, these jobs are mostly carried out by modern equipment and mechanization, which facilitates the work, reduces the impact of labour on the quality and dynamics of works, achieves greater operational reliability, and signifycantly affects the speed of performance of certain work items. In order to make more rational use of the railway closure, the machines are grouped in operation so that after their passage a regulated track is obtained. During the above period heavy machinery was developed which, with great effect, performs a large number of operations within the permitted closure time of the railway. Taking into account that in the last few years the works on the overhaul of the superstructure and the substructure of the railways under the jurisdiction of the Serbian Railways have been intensified, the opportunity has been taken to analyse the existing and relatively available technologies for carrying out track overhaul works, such as:

- track replacement by a quick replacement train;
- track replacement with UK 25-28 cranes;
- replacement with DESEC or hydraulic motor portal cranes.

Remont gornjeg stroja se, po pravilu, izvodi pod zatvorom koloseka i uz ograničenje brzine kretanja vozova.

Ključna pozicija u izvođenju radova na remontu gornjeg stroja - zamena kolosečne rešetke, odnosno demontaža i ponovna montaža iste, se može obavljati na više načina, i to u zavisnosti od:

- potreba investitora,
- dinamičko plana izvođenja radova,
- količina radova i
- ekonomske opravdanost.

Dugo vremena su radovi na održavanju i remontu gornjeg stroja železnica izvođeni ručno, prvenstveno zbog intenzivnog saobraćaja na prugama i nemogućnosti njihovog zatvaranja dovoljno dugo vremena. To je i bio osnovni preduslov za upotrebu mehanizacije [1]. Situacija je značajno napredovala u poslednjih pedesetak godina. Danas se ovi poslovi najčešće obavljaju korišćenjem moderne opreme i mehanizacije čime se olakšava rad, smanjuje uticaj fizičke radne snage na kvalitet i dinamiku radova, postiže veća operativna pouzdanost, kao i značajno utiče na brzinu izvođenja određenih pozicija rada. Zbog racionalnijeg korišćenja zatvora pruge, mašine se grupišu u radu tako da se nakon njihovog prolaska dobija regulisan kolosek. Tokom pomenutog perioda su razvijene teške mašine koje sa velikim učinkom obavljaju veliki broj operacija u dozvoljenom vremenu zatvora pruge.

Uzimajući u obzir da su u nekoliko poslednjih godina intenzivirani radovi na remontu gornjeg i donjeg stroja pruga u nadležnosti Železnica Srbije, iskorišćena je prilika da se analiziraju postojeće i relativno dostupne tehnologije za izvođenje radova na remontu koloseka, i to:

- zamena koloseka pomoću voza za brzu zamenu;
- zamena koloseka pomoću kranova UK 25-28;
- zamena DESEC ili hidrauličnim motornim portalnim kranovima.

2. TRACK REPLACEMENT BY A QUICK REPLACEMENT TRAIN

In 1974, the Austrian company Plasser & Theurer [2] developed an assembly line technology (SUZ 2000) for the rapid replacement of the track, which consisted of machines for ejecting rails from bearing plates and automatically returning new rails, pre-arranged along the railway line. The same machine collected old sleepers and transported them to the first wagon beside the machine, where the special portal crane, traveling along the crane line placed on wagons, carried them away to allocated wagons. The same cranes would bring new sleepers to the first wagon and the machine would lay the new track. Austrian company has continued to develop this technology, so that machines for ejecting old crushed stone, excavating the ballast layer, as well as laying ballast, with rolling and arrangement [2], have been added to this platform. In this way a complete and continuous process of overhauling the superstructure was achieved (Figures 1 and 2).

2. ZAMENA KOLOSEKA POMOĆU VOZA ZA BRZU ZAMENU

Austrijska kompanija Plasser & Theurer [2] je 1974. godine razvila tehnologiju montažne linije (SUZ 2000) za brzu zamenu koloseka, koju su činile mašina za izbacivanje šina iz podložnih ploča i automatsko vraćanje novih šina, prethodno raspoređenih po trasi pruge. Ista mašina je prikupljala stare pragove i pomoću transportnih traka ih transportovala na prvi vagon do mašine, odakle su ih specijalni portalni kranovi, krećući se kranskom stazom koja se nalazila na vagonima odnosili na za njih predviđene vagone. Isti kranovi bi doneli nove pragove na prvi vagon i mašina bi polagala novi kolosek.
Austrijska kompanija je nastavila usavršavanje ove tehnologije, tako da su na ovu platformu dodate mašine za izbacivanje starog tucanika, iskop tamponskog sloja, kao i ugradnju tampona, sa valjanjem i uređenjem [2]. Time je postignut kompletan i kontinuiran proces remonta gornjeg stroja (Slike 1 i 2).

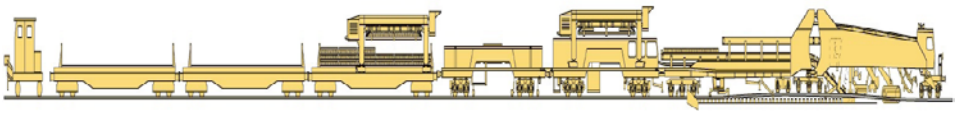

Figure 1 - Schematic presentation of the track replacement by a quick replacement train [2]
Slika 1 - Šematski prikaz zamene koloseka vozom za brzu zamenu [2]

Figure 2 - Train SUZ 500 UVR for quick replacement of track [2]
Slika 2 - Voz SUZ 500 UVR za brzu zamenu koloseka [2]

3. TRACK REPLACEMENT WITH UK 25-28 CRANES

Russian technology for track replacement by using IK 25-28 cranes [3] consists of two operations, i.e.: disassembly the old tracks and placement of the new one (Figure 3). In the meantime, by means of classic construction mechanization (excavators, bulldozers, trucks, graders, etc.), crushed stone ballast is removed and, if anticipated by the design, works on substructure of the railway are carried out (Figure 3).
Disassembly of the old panel is carried out by means of working train consisting of laying crane UK 25 or 28 (Figure 4), open motor wagons MPD-2 and open wagons USO (Figure 5). Disassembly is performed in segments of railway track panel approximately 25 m long, with loading the track panels to wagons.

3. ZAMENA KOLOSEKA POMOĆU KRANOVA UK 25-28

Ruska tehnologija za zamenu koloseka pomoću UK 25-28 kranova [3] se sastoji iz dve operacije, i to: demontaža starog koloseka i montaža novog (Slika 3). U međuvremenu se uz pomoć klasične građevinske mehanizacije (bageri, buldozeri, kamioni, grejederi, itd) izbacuje tucanički zastor i, ukoliko je to predviđeno projektom, obavljaju radovi na donjem stroju pruge (Slika 3).
Demontaža stare rešetke se obavlja pomoću radnog voza koji se sastoji od krana za polaganje UK 25 ili 28 (Slika 4), motornih otvorenih vagona MPD-2 i otvorenih vagona USO (Slika 5). Demontaža se obavlja u segmentima kolosečne rešetke dužine cca 25 m, sa utovarom kolosečnih polja na vagone.

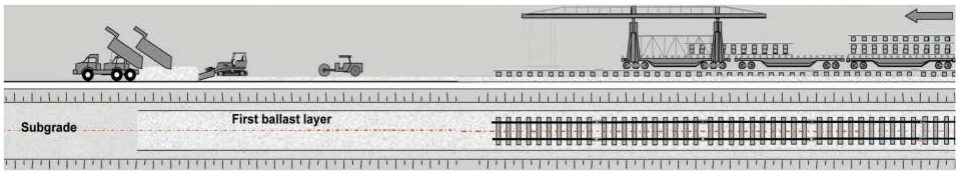

Figure 3 - Schematic presentation of track laying with the crane UK 25-28 [3]
Slika 3 - Šematski prikaz polaganja koloseka kranom UK 25-28 [3]


Figure 4 - Crane UK 25-28 for track laying [3]
Slika 4 - Kran UK 25-28 za polaganje koloseka [3]

Figure 5 - Opened motor wagon MPD-2 and opened wagon USO [3]
Slika 5 - Otvoreni motorni vagon MPD-2 i otvoreni vagon USO [3]

Track mounting is performed using the same train assembly, with pre-mounted track panels on the mounting yard. The length of the new panels is 25.2 m and only because of the length of the panels used rails are usually placed. Laying of the track is done by lowering the mounted track panels in front of the crane, on the prepared alignment, fastening the rails with classic fish-plates, so that the crane itself can cross over the them. When the track is laid, by means of ZPK cranes new long rails are brought and distributed, pre-mounted panels are unscrewed, and rails are replaced.

4. TRACK REPLACEMENT WITH DESEC OR HYDRAULIC MOTOR PORTAL CRANES

Replacement of track with portal cranes DESEC or DONELLI PD 35 is different in the use of crane track. The removal and assembly of tracks with DONELLI cranes (Figures 6 and 7) requires the construction of a crane track [4], while the DESEC cranes (Figures 8 and 9) have continuous tracks and do not require an auxiliary path [5].
For both machines, track replacement requires a composition consisting of the cranes themselves and the special wagon for their transportation, the traction device (locomotive, draisine) and the platform wagon without the sides for transporting old and new sleepers (Figures 6 and 8).

Montaža koloseka se vrši korišćenjem iste kompozicije, sa prethodno namontiranim poljima na montažnom placu. Dužina novih polja je 25,2 m i samo zbog dužine polja se obično radi sa polovnim šinama. Polaganje koloseka se obavlja tako što se ispred krana, na pripremljenu trasu, spuštaju namontirana polja, vezuju se sastavi šina klasičnim kolosečnim vezicama, kako bi sam kran mogao da pređe preko istih. Kada se položi kolosek, pomoću ZPK kranova se dovlače i raspoređuju nove dugačke šine, odvijaju se već montirana polja i menjaju šine.

4. ZAMENA KOLOSEKA DESEC ILI HIDRAULIČNIM MOTORNIM PORTALNIM KRANOVIMA

Zamena koloseka pomoću portalnih kranova DESEC ili DONELLI PD 350 se razlikuje u upotrebi kranske staze. Za demontažu i montažu koloseka sa DONELLI kranovima (Slike 6 i 7) je potrebna izrada kranske staze [4], dok DESEC kranovi (Slike 8 i 9) poseduju gusenice za kretanje te za njih nije potrebna pomoćna staza [5].
Kod obe mašine, za potrebe rada na zameni koloseka, je potrebna kompozicija koja se sastoji od samih kranova i specijalnog vagona za njihov transport, vučnog sredstva (lokomotiva, drezina) i plato vagona bez stranica za transport starih i novih pragova (Slike 6 i 8).
U slučaju rada sa DONELLI kranovima, prvo se od polovnih šina formira

In the event of working with DONELLI cranes, an auxiliary 180 m long crane track is formed from old rails on both sides of the track, 330 cm wide for operation of motor portal cranes.

pomoćna kranska staza dužine 180 m, sa obe strane koloseka, širine 330 cm za kretanje motornih portalnih kranova.

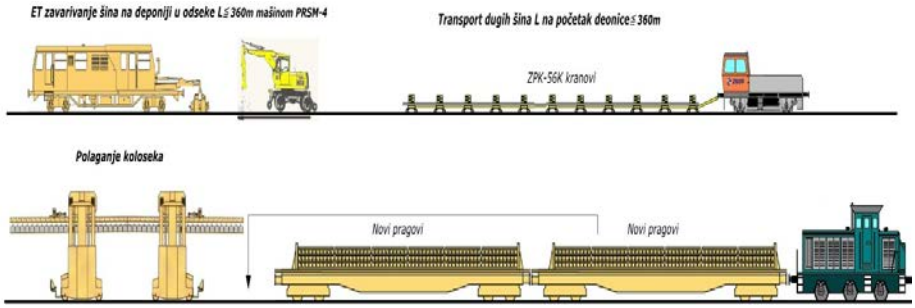

Figure 6 - Schematic presentation of track laying by hydraulic motor portal cranes DONELLI PD 350 [4]
Slika 6 - Šematski prikaz polaganja koloseka hidrauličnim motornim portalnim kranovima DONELLI PD 350 [4]

Figure 7 - Hydraulic motor portal crane DONELLI PD 350 [4]
Figure 7 - Hidraulični motorni portalni kran DONELLI PD 350 [4]

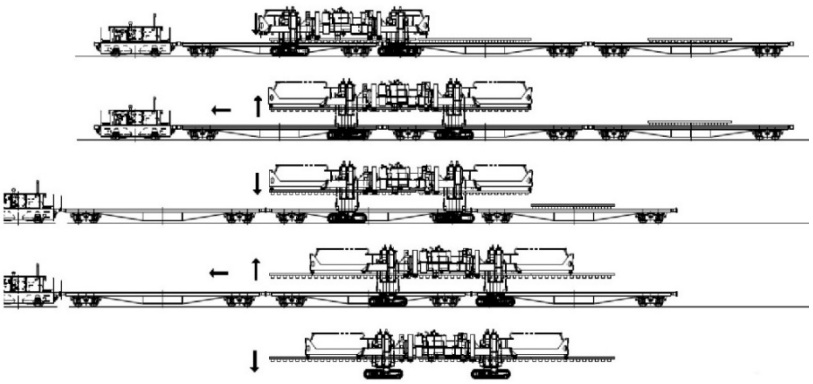

Figure 8 - Schematic presentation of track laying with the DESEC crane [5]
Slika 8 - Šematski prikaz polaganja koloseka DESEC kranom [5]

Figure 9 - DESEC crane for laying tracks and switches [5]
Figure 9 - DESEC kran za polaganje koloseka i skretnica [5]

The existing track is cut with oxyacetylene apparatus in rail panels 30-45 m long rail panels are then lifted and loaded to empty platform wagons with hydraulic cranes. The procedure of lifting rail panels, longitudinal transfer and loading to platform wagons continues until the planned daily performance is met.
After lifting the rail panels, locomotive pulls crane path to the part of the track that has not been planned for day work.
Laying of track is carried out after the first layer of ballast is placed. With a light bulldozer, new rails, 120-240 m long, are brought to the section of the track intended for operation, and they are used to form a crane path.
After the crane path is created, the composition used for disassembly is brought again and new sleepers are placed to a specified distance by using cranes. Following that, the rails used for the crane track are inserted into the base plates on the sleepers with a special machine for manipulating the rails MPR and the track is fastened.

5. TECHNOLOGIES COMPARISION

In order to select the most economical and the most practical technology for performing a track replacement works during the overhaul of railway superstructure in Serbia, a comparison of the above technologies was made taking into account several factors:

Postojeći kolosek se autogenim aparatom seče u šinska polja dužine 30-45 m, zatim se šinska polja dižu i utovaraju u prazne plato vagone hidrauličnim kranovima. Postupak dizanja šinskih polja, podužni prenos i utovar na plato vagone se nastavlja do završetka planiranog dnevnog učinka.
Nakon dizanja šinskih polja, lokomotivom se povlači kranska staza na deo koloseka koji nije predviđen da se radi toga dana.
Montaža koloseka se vrši po završetku izrade prvog sloja zastorne prizme. Lakšim buldozerom se dovlače nove šine, dužine 120-240 m na deo koloseka koji je predviđen za rad, i od njih se formira kranska staza.
Nakon izrade kranske staze, ponovo se dovlači kompozicija korišćena za demontažu i pomoću kranova se spuštaju novi pragovi na zadato odstojanje. Nakon toga se šine koje su služile za kransku stazu ubacuju u podložne ploče na pragovima specijalnom mašinom za manipulaciju šinama MPR i vezuje se kolosek.

5. UPOREĐENJE TEHNOLOGIJA

Da bi se odabrala najekonomičnija i najpraktičnija tehnologija za izvođenje radova na zameni koloseka tokom remonta gornjeg stroja pruga u Srbiji, izvršeno je upoređenje gore navedenih tehnologija po nekoliko faktora:
- cena mašina potrebnih za konkretnu vrstu tehnologije;

- price of machines required for the specific type of technology;
- price of work with specific technologies, where the availability of certain machines at the market is of greatest importance;
- specificity technologies in relation to characteristics of railway alignment;
- works schedule and necessity of faster work and shorter periods of railway closure, and daily performance of machines.

Quick replacement train

Quick replacement train is the most expensive machine for this type of work worldwide, it is manufactured per special order and in the entire Europe there are only few companies that possess this machine. An additional factor that may affect speed of works implementation and recommendation is period of time required for production of this machine - two years at least.
As an example of high costs, in this case of works in Serbia, in 2004 a company owning quick replacement train offered the works for price four times higher than other companies, that competed for the job, but with other technologies.
Save for 700 m of tracks for machine itself, which is that long, no additional space is required for other special preliminary works and preparations. Problems in using the quick replacement train are railway crossings at level that are very frequent in Serbia and it is unprofitable to switch off such machine to be able to use the crossings for the road traffic.
As far as dynamics is concerned, with this quick replacement machine it is possible to carry out much bigger sections of the railway with shorter closures than any other technology.

UK 25-28 cranes

All the machines needed for this system were originally made for track widths of

- cena rada određenim tehnologijama, gde je naročito važna dostupnost pojedinih mašina na tržištu;
- specifičnost tehnologija u odnosu na same karakteristike trase pruge;
- dinamika radova i potreba za bržim radom u kraćim zatvorima pruge, i dnevni učinak mašina.

Voz za brzu zamenu

Voz za brzu zamenu je najskuplja mašina za ovu vrstu radova u čitavom svetu, proizvodi se po specijalnoj narudžbini i u čitavoj Evropi postoji samo nekoliko preduzeća koje poseduju ovaj stroj. Dodatni faktor koji može uticati na brzinu realizacije poslova i preporuku je vreme proizvodnje ovog stroja - najmanje dve godine.
Kao primer visokih troškova, u ovom slučaju rada, navodi se da je u Srbiji, tokom 2004. godine, preduzeće koje poseduje voz za brzu zamenu ponudilo rad koji je bio četiri puta skuplji od ostalih preduzeća koja su se nadmetala za dobijanje posla, ali sa drugim tehnologijama.
Za voz za brzu zamenu, osim oko 700 m koloseka za sam stroj koji je toliko dugačak, nije potrebno više prostora za neke posebne predradnje i pripreme. Problemi kod korišćenja voza za brzu zamenu su ukrštaji puta i pruge u nivou koji su u Srbiji izuzetno česti i neisplativo je isključivati ovakvu mašinu kako bi isti mogli da se koriste za drumski saobraćaj.
Što se same dinamike tiče, pomoću stroja za brzu zamenu se može u kratkim zatvorima pruge uraditi mnogo više pruge nego sa bilo kojom drugom tehnologijom.

Kranovi UK 25-28

Sve mašine koje su potrebne za ovaj stroj su prvobitno pravljene za koloseke širine 1.500 mm. Za rad sa ovim strojem

1,500 mm. This machine requires special wagons, special traction devices and the crane itself, which is more expensive than a machine required for technology with DESEC or portal cranes.
Two compositions with this technology operate currently in Serbia. Price of work with this technology is more expensive that the technologies used by DESEC or portal cranes.
This machine requires great number of tracks for pre-mounting of panels, which does not represent an issue in Russia, i.e in Asia in general (where it is most frequently used), while at the railroads of Serbian Railways this poses a big issue. When working with this technology in Serbia, it is difficult, and sometimes even impossible, to maintain normal and regular traffic, or station manoeuvres where the material deposits are placed.
When using UK 25-28 cranes, according to the manufacturer's specification, for a single composition, the daily performance is 1 km of track dismantling or laying, however, if all the preliminary works and works after the main items are taken into account, much more time is required for 1 km.

DESEC or hydraulic motor portal cranes

Before the Russian Railways arrived in Serbia in 2004, this technology was the most common technology in this region. Machine prices for a complete setup are cheaper than previous technologies, since the machines used here are machines that are not specialized for only railway overhaul works, such as locomotives (manoeuvring locomotives that are produced in series) and wagons also used for various purposes. Only cranes are ordered specifically for railway overhaul, but they are far cheaper and more simple than quick replacement train and UK 25-28 cranes. It does not require large pre-processing and large pre-assembly spaces, which is a great advantage in Serbia.

su potrebni specijalni vagoni, specijalna vučna sredstva i sam kran, koji su skuplji od stroja potrebnog za tehnologiju sa DESEC ili portalnim kranovima.
U Srbiji trenutno rade dve kompozicije ovom tehnologijom. Cena rada ovom tehnologijom je skuplja od tehnologije koju koriste DESEC ili portalni kranovi.
Za ovakav stroj je potreban veliki broj koloseka za predmontažu polja, što u Rusiji, odnosno uopšte Aziji (gde su najviše zastupljeni) nije problem, dok je na prugama Železnica Srbije to veliki problem. Kada se radi ovom tehnologijom u Srbiji, teško je, a ponekad i nemoguće odvijanje redovnog i normalnog saobraćaja, kao ni staničnih manevara gde se nalaze deponije materijala.
Korišćenjem kranova UK 25-28, prema specifikaciji proizvođača, za jednu kompoziciju dnevni učinak iznosi 1 km demontaže ili montaže koloseka, međutim kada se dodaju sve predradnje i radnje koje se dešavaju nakon glavnih pozicija za 1 km je potrebno mnogo više vremena.

DESEC ili hidraulični motorni portalni kranovi

Ovo je tehnologija koja je pre dolaska Ruskih Železnica 2004. godine u Srbiju bila najzastupljenija na ovim prostorima. Cene mašina za kompletan stroj su jeftinije od prethodnih tehnologija, najviše zbog toga što se za nju koriste mašine koje nisu specijalizovane samo za radove na remontu pruge, a to su lokomotive (manevarske lokomotive koje se proizvode serijski) i vagoni koji se takođe koriste u razne svrhe. Samo se kranovi naručuju specijalno za remont pruge, ali su daleko jeftiniji i jednostavniji od voza za brzu zamenu i UK 25-28 kranova.
Nisu potrebne velike predradnje i veliki prostori za predmontažu, što je u Srbiji velika prednost.

The advantage of this technology over the Russian is that some positions are not performed twice, and there is no need to cut rails to shorter lengths then 40 m during the work.
Due to all of the above, the cost of work with this technology is the cheapest.
This technology can also be used in shorter railway closures, but the performance is up to 7 times lower than quick replacement train.

6. CONCLUSION

The aforementioned overview and comparison of technologies for overhauling the railway superstructure clearly indicates that the most economical and most practical track replacement technology during the overhaul of railways under the authority of Serbian Railways is track replacement with DESEC or hydraulic portal cranes. This is particularly significant taking into account big investments in overhaul of superstructure of railways in the Republic of Serbia that took place over the last few years, putting the state in debts through loans from international financial institutions or through commercial credits, At the same relatively long period of time, while the works take place, the state will not be able to acquire revenue from operation (regardless if the traffic previously took place or not, and under which conditions), and use it for improvement of the condition, as well as for repaying the loans.

Prednost ove tehnologije nad ruskom je i što se neke pozicije ne rade dva puta, kao i što prilikom rada nije potrebno seći šine na kraće dužine od 40 m.
Cena rada ovom tehnologijom je zbog svega gore navedenog najjeftinija.
Ova tehnologija se može koristiti i prilikom manjih zatvora pruge, ali je učinak i do 7 puta manji od voza za brzu zamenu.

6. ZAKLJUČAK

Napred navedeni prikaz i upoređenje tehnologija za remont gornjeg stroja pruga jasno ukazuje na činjenicu da je najjekonomičnija i najpraktičnija tehnologija za zamenu koloseka na remontima pruga u nadležnosti Železnice Srbije zamena koloseka pomoću DESEC ili hidrauličnih portalnih kranova. Ovo je posebno značajno u odnosu na velike investicije koje se odvijaju poslednjih nekoliko godina na remontu gornjeg stroja pruga u Republici Srbiji za koje se država zadužuje kroz kredite međunarodnih finansijskih institucija ili komercijalne kredite, a u relativno dugom vremenu dok traju radovi nije u mogućnosti da ubira prihode od eksploatacije (bez obzira da li se prethodno saobraćaj odvijao ili nije, i pod kojim uslovima) i iskoristi ih kako za unapređenje stanja, tako i za vraćanje kreditnih obaveza.

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